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Effect of Modic Changes in Cervical Degenerative Disease

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Objective: Modic changes are signal intensity changes in adjacent vertebral bone marrow on magnetic resonance imaging. Few studies have investigated these changes with regard to the cervical spine. In this study, we investigated the associations between cervical degenerative disease and Modic changes.

Methods: We conducted a retrospective collection of radiological data in patients with neck pain at Pusan National University Yangsan Hospital from January 2010 to December 2014. A total of 169 patients were included in this study. Disc herniation grade, disc space height and global cervical lordosis (C2-C7 Cobb angle) were measured and analyzed. If Modic changes were present, we recorded the Modic change type based on the literature, vertebral level, age, sex, and surgical requirement.

Results: Sixty-six patients exhibited Modic changes in the cervical spine. Out of these 66 patients, Modic change type II (56 patients, 84.8%) and C5–6 vertebral level (23 patients, 34.8%) were the most predominant categories. Patients with Modic change showed worse outcomes in regard to disc herniation grade, disc space height and global cervical lordosis than patients without ($p<0.01$). Among 169 patients, 18 patients had undergone anterior cervical discectomy with fusion (ACDF). Patients with Modic changes (10 of 66 patients, 15.1%) had a greater probability of undergoing ACDF than those without (8 of 103 patients, 7.8%; $p<0.01$).

Conclusion: Modic changes refer cervical degenerative changes, and incidence of ACDF is higher when the Modic changes are occurred.

Key Words: Cervical vertebrae, Intervertebral disc degeneration, Magnetic resonance imaging

INTRODUCTION

Cervical degenerative disease is a chronic degenerative process. The incidence of cervical spine degenerative disease has been rising owing to the increasing aging population. Magne tic resonance imaging (MRI) has been used to determine cervical degenerative diseases in patients with axial symptoms[2]. Modic changes (MCs) comprise signal intensity alterations in adjacent vertebral bone marrow on MRI[1,8]. Since these changes were first introduced by Modic et al.[8] in 1988, many studies have investigated their relationship with spinal degenerative diseases. MCs have not been shown to reflect spinal tumor, pyogenic spondylitis, or rheumatic disease, but have been found to be associated with pathological changes in bone marrow composition[3,10]. MCs have been divided into three types by MRI[8], type I: low signal intensity on T1-weighted imaging and high signal intensity on T2-weighted imaging (Fig. 1), type II: high signal intensity on T1-weighted and T2-weighted imaging (Fig. 2), and type III: low signal intensity on T1-weighted and T2-weighted imaging (Fig. 3). Modic type I is an inflammatory phase in which the vertebral endplates become cracked and disrupted, eventually converting to type II within 3 years. Modic type II is a fatty involution phase that is more common in the lumbar spine and replaced with yellow fatty marrow in vertebral endplates. Modic type III is a cicatrization phase; there is little marrow owing to replacement with bony sclerosis[7,8]. Many studies have attempted to investigate MCs in the lumbar spine. However, few studies have assessed these changes in regard to the cervical spine. In this study, we investigated the associations between cervical degenerative disease and MCs.

MATERIALS AND METHODS

1. Patients

We conducted a retrospective collection of radiological data in patients with one-level cervical degenerative diseases at Pusan National University Yangsan Hospital from January 2010 to December 2014. Patients were included if they fulfilled the following criteria: (1) no his

tory of cervical spinal surgery; (2) absence of concomitant spinal disease (spinal tumor, infection, fracture or immune disease); and (3) no history of recent trauma. A total of 169 patients were included in this study. The patient study group comprised 79 men and 90 women; the mean age was 50.7±10.3 years (range, 30–80 years). Classification of MCs was based on the literature and mixed types were not considered.

2. Assessment of Degenerative Change

All of radiological assessments were performed by 2 independent observers highly experienced in spinal diseases. Disc herniation (DH) at each level was assessed by examining T2-weighted sagittal images. DH grade was divided into 4 grades according to modified Matsumoto's classification[6] as follows: grade 1, disc bulging beyond the posterior margin of the vertebral body; grade 2, disc bulging over half of epidural space; grade 3, disc protrusion bordering the spinal cord; and grade 4, disc protrusion compressing the spinal cord. To evaluate the global cervical lordosis (C2–C7 Cobb angle) (GCL) and disc space height (DSH), we measured the lateral radiographs of the cervical spine in neutral position. DSH was evaluated by measuring the mean value of anterior and posterior DSHs at each level. GCL is the angle formed between a line drawn parallel to the inferior endplate of C2 vertebral body and a line drawn parallel to the inferior endplate of C7 vertebral body. If MCs were present, we recorded the Modic type, vertebral level, age, sex, and surgical requirement.

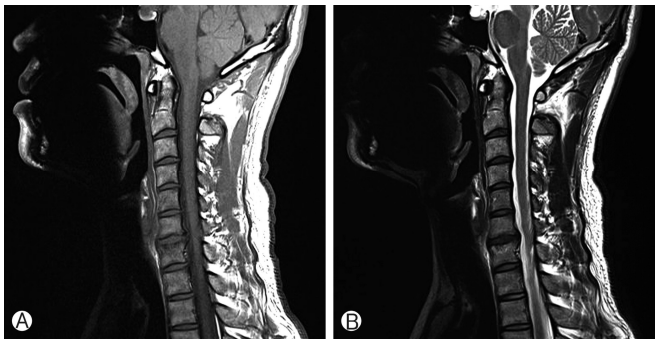

Fig. 1. Modic change type I at C6–7 as a low signal in a T1-weighted image (**A**) and a high signal in a T2-weighted image (**B**).

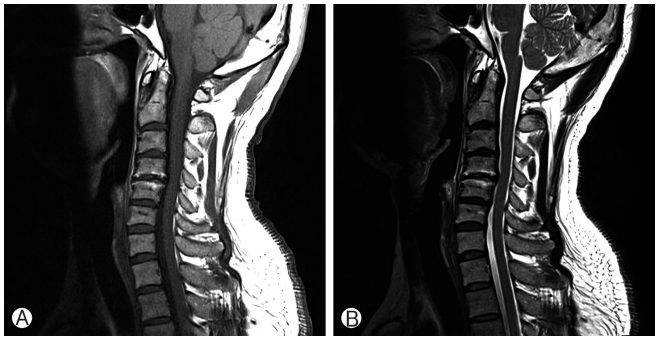

Fig. 2. Modic change type II at C4–5 as a high signal in T1- (**A**) and T2-weighted images (**B**).

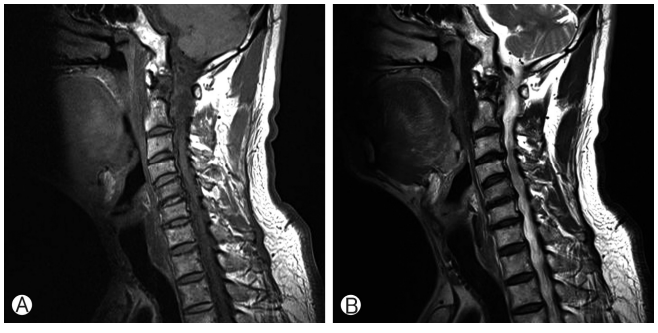

Fig. 3. Modic change type III at C5–6 as a low signal in T1- (**A**) and T2-weighted images (**B**).

3. Statistical Analysis

Results are presented as mean±standard deviation. Statistical analysis was performed using the software package IBM SPSS ver. 18.0 (IBM Co., Armonk, NY, USA). Intergroup results were compared using the Kolmogorov-Smirnov test, chi-square test, Shapiro-Wilk test, independent t-test, and Mann-Whitney U-test. A p-value of <0.05 was considered statistically significant.

RESULTS

MRI scans of the 169 patients were reviewed; 66 patients exhibited MCs in the cervical spine (29.7%). The mean age of patients with MCs was 49.8±10.7 years (range, 30–74 years), the sex distribution was 36:30 (men:women). Out of these 66 patients, 3 patients (4.5%) were classified with Modic type I on MRI. The most common MC observed was type II, 56 patients (84.8%). 7 patients (10.6%) were classified with Modic type III. The most common cervical level in patients with MCs was C5–6 (29 patients, 43.9%); C6–7 (22 patients, 33.3%) showed the second largest number of MCs. The prevalence of MCs are summarized in Table 1.

DH grade and DSH were statistically significantly different between patients with MCs and those without ($p<0.01$ for DH grade and DSH). The outcomes of GCL also showed a statistically significant difference in patients with MCs as compared those

Table 1. Prevalence of Modic changes according to types

Variable	Type I (n=3)	Type II (n=56)	Type III (n=7)
Sex, men:women	3:0	30:26	3:4
Mean age (yr), mean±SD	31.0±1.0	54.1±8.4	56.4±5.7
C2–3	-	3	1
C3–4	-	1	-
C4–5	-	8	2
C5–6	2	23	4
C6–7	1	21	-

SD, standard deviation.

Table 2. Radiological outcomes

Variable	MCs (n=66)	No MCs (n=153)	p-value
Disc height (mm)	5.6±0.9	6.8±1.2	<0.01
Disc herniation grade			<0.01
1	2 (3.0)	56 (36.6)	
2	19 (28.8)	64 (41.8)	
3	31 (47.0)	25 (16.3)	
4	14 (21.2)	8 (5.2)	
Global cervical lordosis (°)	7.06±1.9	8.95±1.0	<0.01

Values are presented as mean±standard deviation or number (%).
MCs, Modic changes.

without. The outcomes of GCL of the patients with MCs were lower compared with the patients without MCs: 7.06±1.9 and 8.95±1.0 in patients with MCs and without ($p<0.01$) (Table 2).

Among 169 patients, 18 patients (8.1%) had undergone anterior cervical discectomy with fusion (ACDF), because there had been no improvement following conservative care. Ten patients (66 patients, 15.1%) with MCs and had undergone. On the contrary, only 8 patients (103 patients, 7.8%) without MCs underwent ACDF ($p<0.01$).

DISCUSSION

Cervical degenerative diseases are defined as chronic degenerative processes associated with radiculopathy or myelopathy. The most common cervical level to experience disc degeneration is C5−6 because it has the greatest level of hyperactivity[5]. Mechanical stress such as repetitive loading or neck activity can lead to injury of the endplate and discs. In the present study, we evaluated the radiologic outcomes in single-level cervical degenerative disease. The findings from the present study also showed a higher frequency of MCs occurring with C5−6 (41.4% of patients) followed by C6−7 (29.3% of patients). Peterson et al.[9] reported that the most common level to exhibit MCs was C5−6. This indicates that structural deterioration due to mechanical stress may influence MCs. Hayashi et al.[4] reported that patients showing MCs had more severe disc degeneration than with those without, which may aggravate spinal cord compression and result in loss of range of motion. The present study also showed that patients with MCs had more aggravated outcomes than those without in regard to DH grade, DSH and GCL. Torkki et al.[11] reported that discs with MCs had higher amounts of cytokines (interleukin-6, interleukin-8, and tumor necrosis factor alpha), which increased level of osteoclastic factors (RANKL, M-CSF, NFATc1, RUNX1, and OSCAR), than those without MCs. We hypothesized that cytokines and other factors in the disc promoted the MCs of the vertebral body and increased the likelihood of surgery with mechanical compression. In this study, ACDF rate was significantly higher in patients with MC (15.1%, 10 of 66) as compared to without. Only 8 of 103 patients (7.8%) required surgery in patients without MCs.

The present study has a few limitations. First, it was designed as a retrospective chart and image review. Therefore, we were unable to make a more detailed comparison at each level, as the total number of cases was small. Second, we did not assess clinical outcomes. In future research, large scale prospective studies should be performed to explore the correlation between MCs and clinical outcomes.

CONCLUSION

In this study, we radiologically investigated MCs in the one-level cervical disease. Our findings indicate that MCs were more likely to have disc degeneration and incidence of ACDF is higher when the MCs are occurred.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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