Observational Study

Lumbar Disc Herniation is a Nonnegligible Factor for the Degeneration of Sacroiliac Joints

Zhixiang Huang, MD[1,2], Guochao Li, MD[3], Weiming Deng, MD[1,2], Meng Liu, MD[1,2], and Tianwang Li, MD, PhD[1,2]

From: [1]Department of Rheumatology and Immunology, Guangdong Second Provincial General Hospital, China; [2]The Second School of Clinical Medicine, Southern Medical University, China; [3]Department of Rheumatology and Immunology, Ganzi Tibetan Autonomous Prefecture Peoples Hospital, China

Address Correspondence:
Tianwang Li, MD, PhD
Department of Rheumatology and Immunology, Guangdong Second Provincial General Hospital
466 Xingangzhong Road
Guangzhou 510317, China
E-mail: litian-wang@163.com

Disclaimer: This study was funded by Grant 2017A030313526 from the Natural Science Foundation of Guangdong Province and B2020015 from the Medical Scientific Research Foundation of Guangdong Province. There was no external funding in the preparation of this manuscript.

Conflict of interest: Each author certifies that he or she, or a member of his or her immediate family, has no commercial association (i.e., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted manuscript.

Manuscript received: 06/09/2020
Revised manuscript received: 10/06/2020
Accepted for publication: 11/06/2020

Free full manuscript:
www.painphysicianjournal.com

Background: Sacroiliac joint (SIJ) abnormality is a potential source of low back pain (LBP), therefore numerous patients receive various treatments because of the degenerative changes of SIJ. However, the outcome is unfavorable for patients because these morphologic alterations are common but not the origins of LBP. Previous studies revealed lumbar fusion and transitional vertebra increased the prevalence of degeneration of SIJ. Lumbar disc herniation (LDH) is one of the most common lumbar diseases, but there is no study regarding the relationship between LDH and SIJ degradation.

Objectives: The aim of this study was to investigate the severity of SIJ degeneration in patients with LBP with LDH. The relationship between degenerative changes of SIJ and LDH was also assessed.

Study Design: Retrospective observational study.

Setting: This study was conducted in 2 medical centers located in southeast and midwest China, respectively.

Methods: Lumbar and pelvic computed tomography (CT) scans of patients with LDH (LDH group) from January 2016 to May 2020 were reviewed using a picture archiving and communication system. The control group was age, gender, and body mass index–matched patients with LBP without LDH. Patients underwent whole abdomen and pelvic CT examinations due to non-musculoskeletal disorders. Scores of SIJ degeneration were compared between patients with LDH and the control group. Differences in SIJ degeneration among patients with LDH with diverse characteristics, symptoms, and complications were also evaluated. Univariate and multivariate linear mixed model (LMM) was chosen to identify the factors associated with SIJ degeneration.

Results: CT examinations of 782 patients with LDH were assessed, whereas 223 patients were in the control group. The SIJ degeneration score of the LDH group and control group were 6.00 (5.00) and 3.00 (4.00) ($P < 0.05$). Age and whether patients suffered from LDH were included in the LMM, which involved all reviewed patients ($P < 0.05$). Regarding the characteristics of LDH, the patients with more herniated discs had more severe SIJ degeneration. The score of SIJ degradation in patients with upper LDH was significantly higher than the other patients with LDH (12.00 [4.00] vs. 6.00 [4.00]; $P < 0.05$). Similarly, more significant SIJ degeneration was observed in patients with LDH who had secondary lumbar spinal stenosis (10.00 [4.00] vs. 5.00 [4.00]; $P < 0.05$). The scores of SIJ degradation were significantly greater in patients with LDH with sciatica, numbness, weakness, and/or cauda equina syndrome. Age and LDH were identified as associated factors for more serious degeneration of SIJ among patients with LDH.

Limitations: The main limitation of this study was the retrospective observational nature. Hence our study described that SIJ degeneration was relevant to LDH, but the causal relationship was uncertain. Magnetic resonance imaging was not chosen in this study.

Conclusions: The SIJ degeneration in patients with LDH was more serious than in individuals without LDH. SIJ degeneration was more significant in patients with LDH with more pathological alterations, symptoms, and complications. Age and LDH relate to SIJ degeneration. Therefore the diagnosis and selection of treatment for SIJ changes should comprehensively consider the coexistence of LDH.

Key words: Lumbar disc herniation, low back pain, sacroiliac joint, degeneration, sciatica, numbness, weakness, cauda equina syndrome, computed tomography, linear mix model

Pain Physician 2021: 24:E357-E365

Approximately 80% of people experience a period of low back pain (LBP) at some point in their lifetime. Because of its high prevalence and critical contribution to disability, LBP raises a considerable financial burden for both patients and medical insurance systems. Because a wide range of diseases may present as LBP, its diagnosis and differential diagnosis are difficult in some cases (1).

Sacroiliac joints (SIJs) have a bearing on 13% to 42% of LBP (2,3). However, SIJ dysfunction is difficult to diagnose because there are rarely established methods to support the diagnosis. Previous studies indicated physical examinations of SIJ lacked diagnostic value because of their limited reliability and validity (4,5). SIJ disorder ascribes to the abnormality of SIJ and its surrounding ligaments, whereas it is hard to clarify the abnormal structure when the provocation tests are performed (6,7). Besides, local anesthetic or glucocorticoid injection under fluoroscopy for SIJ has been considered as ideal diagnostic techniques for SIJ dysfunction, but the definition of positive response varies among different studies (6,8). The false-positive rate of these SIJ block treatments is up to approximately 20% (9).

Although computed tomography (CT) is an effective and convenient method for assessment of LBP in clinical practice, the diagnostic value of this imaging examination on SIJ dysfunction is poor (7). Unfortunately, some clinical practitioners diagnose SIJ dysfunction using a combination of LBP and morphologic changes, such as subchondral sclerosis, joint space narrowing, and osteophytes formation (6,10). These degenerative characteristics are common in the elder population and in individuals with high body mass index (BMI) (11,12). Inaccurate diagnosis leads to unreliable response if invasive therapy is prescribed (13).

Lumbar diseases are linked to the degeneration of SIJ as well. The prevalence rate of SIJ abnormality is 28.5% in patients with the transitional vertebra, which is significantly higher than the patients with LBP without transitional vertebra (14). However, no study has focused on the relationship between lumbar disc herniation (LDH) and degenerative changes of SIJ until now. Therefore this study attempted to evaluate the severity of SIJ degeneration in patients with LBP with LDH. We hypothesized that degenerative changes of SIJ were associated with the severity of LDH, therefore the relationship between the features of LDH and SIJ degradation was investigated further.

Methods

This retrospective, observational study was carried out at Guangdong Second Provincial General Hospital and Ganzi Tibetan Autonomous Prefecture People's Hospital, which are located in southeast and midwest China, from January 2018 to May 2020. Institutional review boards of both hospitals approved this study with a waiver of informed consent for retrospective review of medical records (2019-YXLL-001 and 2018-GYY-01).

Patients

Patients with LBP whose duration was longer than 3 months received CT scans for the lumbar and pelvis. Radiologic images of patients with LDH (LDH group) were retrospectively reviewed, except for individuals who suffered from the following conditions: (1) congenital spinal abnormalities; (2) coexistent or preexisting spine pathology, including one or more bone bridge formation from L1-2 to L5-S1, spondylolisthesis, fracture, infection, and/or tumor; (3) history of lumbar surgery; (4) inflammatory back pain and/or buttock pain (15); (5) neurologic disease, except secondary lumbar spinal stenosis (LSS); (6) metabolic disorders or rheumatic diseases; and/or (7) pregnant women.

The other CT scan images of age-, gender-, and BMI-matched patients with LBP were reviewed (control group). Patients underwent whole abdominal and pelvic CT examination because of abdominal and/or pelvic disorders, while lumbar spinal diseases were ruled out. Patients with one or more of the following conditions were also excluded: (1) history of lumbar invasive treatment; (2) inflammatory LBP and/or buttock pain; (3) neurologic, metabolic, or rheumatic diseases; and/or (4) pregnancy.

Imaging and Clinical Assessment

CT examinations were performed on 2 different scanners in 2 centers. One was a 256-slice CT scanner (Philips Brilliance iCT, Philips Healthcare, Amsterdam, the Netherlands) and the other was a 128-slice CT scanner (Siemens Definition, Siemens Medical Solutions, Erlangen, Germany). Evaluation of LDH and SIJ degeneration was performed through a picture archiving and communication system (Infinitt PACS, Hangzhou, China). Axial, coronal, sagittal, and 3-dimensional reconstructed images were assessed by 2 experienced rheumatologists who have been trained in musculoskeletal radiology, and who were blinded to any clinical information.

In the assessment of LDH, levels of disc herniation

were recorded. Upper LDH referred to the patients who had LDH at L1-2 and/or L2-3 (16). Diagnosis of secondary LSS was used as the criteria, which were mentioned by Andreisek et al (17). A scoring system was chosen for evaluating degenerative changes of SIJ by gauging joint space narrowing, osteophytes, subchondral sclerosis, cysts, and vacuum phenomena (Fig. 1). The maximum points were 18 for each person (Table 1) (10).

Demographic information of all patients was collected prior to CT scans, including age, gender, and BMI. The duration and Visual Analog Scale (VAS) of LBP and the departments that patients attended were recorded. Regarding symptoms and physical examination, unilateral and/or bilateral numbness, weakness, and the positive standard straight leg raising test (SLR) were assessed. Sciatica was defined as the pain that radiated to the posterior thigh and extended to the lower extreme, while the pathway of pain was comparable with LDH at the corresponding level and side according to CT scan (18). Cauda equina syndrome (CES) referred to the dysfunction of micturition, defecation, and/or sexual function and sensory disturbance of the saddle area (19).

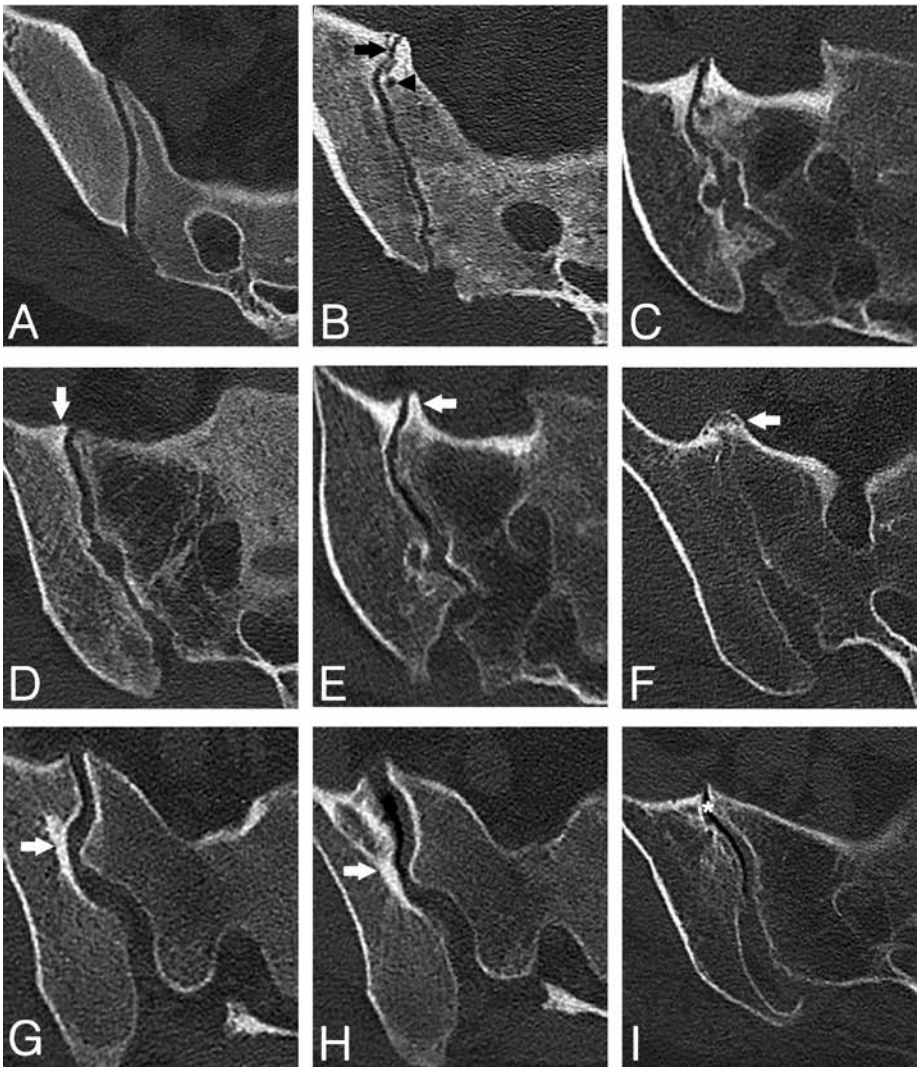

Fig. 1. *Alteration of right SIJs in the CT scans. (A) Normal right SIJ, (B) focal joint space narrowing (arrow) and cyst (arrowhead), (C) general irregular joint space narrowing, (D) minor osteophytes (arrow), (E) prominence osteophytes (arrow), (F) right SIJ ankylosis (arrow), (G) minor subchondral sclerosis (arrow), (H) prominence subchondral sclerosis, (I) vacuum phenomenon (asterisk).*

Statistical Analysis

Statistical analyses were performed using SPSS version 22.0 (IBM Corporation, Armonk, NY). Inter- and intraobserver correlations of SIJ degeneration

Table 1. *Scoring system for unilateral SIJ degeneration.*

Radiologic features	0	1	2	3
Joint space narrowing	Normal	Focal	General irregular	-
Osteophytes	None	Minor	Prominent	Ankylosis
Subchondral sclerosis	None	Minor	Prominent	-
Cysts	None	Exist	-	-
Vacuum phenomenon	None	Exist	-	-

Score of SIJ degeneration for each person is the sum of both SIJs.

scores were calculated using the intraclass correlation coefficient (ICC). Continuous variables were expressed as median (interquartile range) and compared by the Mann-Whitney U test. Categorical variables and constituent ratio were assessed through the χ^2 test. Multiple comparisons were conducted using the Kruskal-Wallis test. *P* value < 0.05 was considered statistically significant.

Univariate and multivariate linear mixed model (LMM) was used to identify factors associated with SIJ degeneration. The score of SIJ degeneration was the dependent variable. In the univariate LMM for all patients, covariates were age, gender, BMI, LDH, duration and VAS of LBP. Variables with statistical significance were modeled with fixed effects. Interaction between age and LDH (age × LDH) was included as a random effect. Similar methods were used to determine the relationship between SIJ degeneration and the characteristics of LDH for patients with LDH.

Results

In 1,005 patients who were reviewed, the number of patients with LDH was 782. The LDH group and control group shared similar demographic features (*P* > 0.05, Table 2). Patients suffered from digestive, urinary, and/or genital diseases in the control group. Regarding the patients with LDH, 227 (29.03%), 335 (42.83%), and 220 (28.13%) of them attended the emergency departments, outpatient clinics, and inpatient wards, which were similar to the control group (76 [34.08%], 101 [45.29%], and 46 [20.63%]; *P* > 0.05).

ICCs of inter- and intraobserver agreement in the score of SIJ degeneration were 0.94 (95% confidence interval [CI], 0.93–0.95) and 0.95 (95% CI, 0.94–0.96), respectively. Based on the comparable demographic background, the SIJ degeneration score of the LDH group and control group were 6.00 (5.00) and 3.00 (4.00). The difference reached statistical significance (*P* < 0.05), therefore SIJ degeneration of patients with LDH was worse than the LDH-free individuals.

Table 3 displays the result of LMM for our patients. Univariate analysis revealed age, BMI, and LDH related to degeneration of SIJ (*P* < 0.05), therefore their fixed effects were further evaluated. Multivariate analysis showed age and LDH associated with the score of SIJ degeneration (*P* < 0.05), whereas age × LDH did not reach statistical significance (*P* > 0.05).

Characteristics of LDH were investigated further. The 1,586 herniated discs in 782 patients included 41 discs (2.59%) at L1-2, 95 discs (5.99%) at L2-3, 199 discs (12.55%) at L3-4, 565 discs (35.62%) at L4-5, and 686 discs (43.25%) at L5-S1. Also, 53 (6.78%), 72 (9.21%), 120 (15.35%), 145 (18.54%), and 392 (50.13%) patients had 1 to 5 levels of LDH. Figure 2 displays the score of SIJ degeneration, while differences reached statistical significance among patients with 1 to 5 levels of LDH (*P* < 0.05).

One hundred and sixteen patients (14.83%) suffered from upper LDH. The scores of SIJ degeneration between patients with LDH with or without upper discs involvement were 12.00 (4.00) and 6.00 (4.00), respectively (*P* < 0.05). Two hundred and sixty-six patients with LDH (14.83%) had secondary LSS. Their score of SIJ degeneration was 10.00 (4.00), which was significantly higher than those patients without this complication (5.00 [4.00], *P* < 0.05).

Table 2. *Demographic and clinical information of patients.*

Parameters	LDH Group (n = 782)	Control Group (n = 223)	*P* Value
Age (years)	48.50 (24.00)	49.00 (34.00)	0.11
Gender (male/female)	313/469	102/121	0.13
BMI (kg/m2)	23.88 (4.43)	23.47 (4.76)	0.27
Duration of LBP (years)	1.04 (1.30)	1.13 (1.09)	0.13
VAS of LBP	7.00 (4.00)	7.00 (3.00)	0.10

Table 3. *LMM for all patients.*

Variables	Univariate Model			Multivariate Model		
	Estimate	95% CI	*P* Value	Estimate	95% CI	*P* Value
Age	0.17	0.17–0.18	< 0.01	0.17	0.03–0.31	0.04
BMI	0.08	0.02–0.13	0.01	0.01	–0.01 to 0.04	0.27
LDH	2.44	1.92–2.96	< 0.01	1.27	0.65–1.88	< 0.01
Gender	–0.30	–0.76 to 0.16	0.20	–	–	–
Duration of LBP	0.12	–0.08 to 0.21	0.24	–	–	–
VAS of LBP	–0.05	–0.17 to 0.07	0.39	–	–	–

Regarding the symptomatology, sciatica was highly prevalent in our patients with LDH, which affected 292 (37.34%) patients. Their degeneration of SIJ was more serious, compared with the other patients with LDH (10.00 [3.00] vs. 5.00 [3.00]; $P < 0.05$). Two hundred and seventy-three (34.91%) patients with LDH complained of the numbness of their lower extremes. Their score of SIJ degeneration was 11.00 (2.00), which was significantly higher than the patients with LDH without numbness (5.00 [3.00]; $P < 0.05$). Weakness of legs was reported in 224 (28.64%) of our patients with LDH. Their severity of SIJ degradation was significantly greater than the other patients with LDH (10.00 [2.00] vs. 5.00 [3.00]; $P < 0.05$). Physical examinations showed 386 (49.36%) patients with LDH had a positive result of SLR, but their score of SIJ degeneration was comparable to the other patients with LDH (6.00 [6.00] vs. 6.00 [5.00]; $P > 0.05$). Only 10 (1.28%) patients with LDH suffered from CES, while their score of SIJ degradation was 14.50 (4.00), which was significantly higher than the other patients with LDH (6.00 [5.00]; $P < 0.05$).

In the LMM for patients with LDH, univariate analysis showed age, BMI, duration of LBP, and characteristics of LDH, except SLR, were related to the severity of SIJ degeneration (Table 4). Because levels of LDH, upper LDH, secondary LSS, sciatica, numbness, weakness, and CES significantly correlated with each other ($P < 0.05$), one of them could be included in a multivariate LMM. Therefore 7 models were used to explore the relationship between LDH and SIJ degradation. Relationship between features of LDH and SIJ degeneration are shown in Table 5, whereas the association between clinical manifestations and degradation of SIJ are displayed in Table 6. All models revealed age and LDH associated with the score of SIJ degeneration ($P < 0.05$). Age × features of LDH did not reach statistical significance ($P > 0.05$).

Discussion

LBP is highly prevalent in the middle-aged and elderly population. Chronic LBP with a duration of more

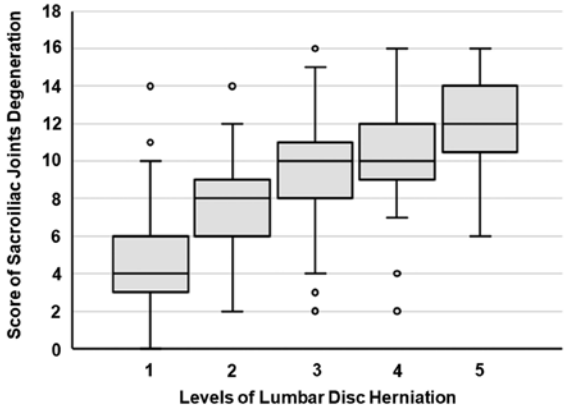

Fig. 2. *The score of SIJ degeneration in patients with different LDH levels.*

Table 4. *Univariate LMM for patients with LDH.*

Variables	Estimate	95% CI	*P* Value
Age	0.18	0.17–0.19	< 0.01
Gender	–1.26	–0.62 to 0.37	0.62
BMI	0.08	0.01–0.14	0.02
Duration of LBP	0.24	0.03–0.44	0.02
VAS of LBP	–0.09	–0.21 to 0.03	0.16
Levels of LDH	2.00	1.87–2.13	< 0.01
Upper LDH	–4.68	–5.28 to –4.09	< 0.01
Secondary LSS	–4.40	–4.81 to –4.00	< 0.01
Sciatica	–5.79	–6.08 to –5.50	< 0.01
Numbness	–5.76	–6.07 to –5.45	< 0.01
Weakness	–5.78	–6.13 to –5.43	< 0.01
SLR	–0.41	–0.89 to 0.07	0.10
CES	–6.95	–9.05 to –4.85	< 0.01

Table 5. *Multivariate LMM about features of LDH.*

Variables	Model 1			Model 2			Model 3		
	Estimate	95% CI	*P* Value	Estimate	95% CI	*P* Value	Estimate	95% CI	*P* Value
Age	0.14	0.13–0.15	< 0.01	0.17	0.16–0.18	< 0.01	0.16	0.15–0.17	< 0.01
BMI	0.01	–0.01 to 0.04	0.32	0.02	–0.01 to 0.05	0.18	0.03	0.00–0.06	0.07
Duration of LBP	0.15	0.05–0.24	< 0.01	0.12	0.01–0.21	0.03	0.11	0.01–0.21	0.03
Levels of LDH	0.75	0.62–0.87	< 0.01	–	–	–	–	–	–
Upper LDH	–	–	–	–0.99	–1.37 to –0.61	< 0.01	–	–	–
Secondary LSS	–	–	–	–	–	–	–1.04	–1.35 to –0.73	< 0.01

Table 6. *Multivariate LMM about symptoms and complication of LDH.*

Variables	Model 1			Model 2			Model 3			Model 4		
	Estimate	95% CI	*P* Value	Estimate	95% CI	*P* Value	Estimate	95% CI	*P* Value	Estimate	95% CI	*P* Value
Age	0.12	0.11–0.13	< 0.01	0.16	0.11–0.14	< 0.01	0.14	0.13–0.15	< 0.01	0.18	0.17–0.18	< 0.01
BMI	0.02	−0.01 to 0.05	0.13	0.03	0.00–0.06	0.02	0.04	0.01–0.07	0.01	0.03	−0.01 to 0.06	0.12
Duration of LBP	0.13	0.04–0.23	0.02	0.12	0.02–0.21	0.02	0.13	0.03–0.22	0.01	0.07	−0.04 to 0.18	0.21
Sciatica	−2.49	−2.87 to −2.11	< 0.01	–	–	–	–	–	–	–	–	–
Numbness	–	–	–	−2.28	−2.66 to −1.90	< 0.01	–	–	–	–	–	–
Weakness	–	–	–	–	–	–	−1.68	−2.11 to −1.26	< 0.01	–	–	–
CES	–	–	–	–	–	–	–	–	–	−1.19	−2.35 to −0.04	0.04

than 4 weeks corresponds to lumbar discopathy on CT or magnetic resonance imaging (MRI) examination (20). However, abnormality in many different structures can result in LBP including but not limited to the pathological changes in the intervertebral discs and vertebral bodies. SIJ abnormality may act as a possible source of LBP. Some clinical practitioners ascribe LBP to the degenerative changes of SIJ, without considering the other underlying causes. Then the unnecessary invasive interventions are administered, while poor responses in patients are commonly reported. The key point is the unawareness of the relationship between lumbar diseases and morphologic alterations of SIJ, therefore we sought to evaluate the link between LDH and the degradation of SIJ. This study reveals SIJ degeneration is more serious in patients with LDH, compared with the control individuals. The greater severity of LDH, more symptoms and/or complications relates to more significant changes in SIJ as well. The relationship between LDH and SIJ degeneration is comparable to that between age and the degradation of SIJ.

Because gender, age, and BMI may link to the severity of SIJ degeneration, age-, gender-, and BMI-matched patients with LBP were set as the control group (11,21). Based on a similar background, the score of SIJ degeneration in the LDH group was significantly higher than the control group. Previous studies proved lumbar diseases trigger abnormality of SIJ. For example, Lee et al (22) found 38 patients who developed new-onset SIJ pain in 317 individuals who underwent lumbar fusion. This operation also leads to the degradation of SIJ in CT assessments (23). In terms of some degenerative lumbar spinal disorders, mobility of SIJ markedly decreases, according to a study that used low-dose 3-dimensional CT to monitor the kinematic properties (24). Telli et al (25) also showed SIJ dysfunction was a common complication in one-third of patients with LDH. These studies support our results, which indicates that patients with LDH may have more radiologic changes. A probable explanation for this phenomenon is that alterations of lumbar may change the angular motions and stress across SIJ (26).

To find potential factors related to the degeneration of SIJ, univariate and multivariate analyses were performed. Regarding the non-normal distribution of continuous variables, LMM was chosen in this study (27). Age and whether individuals suffered from LDH related to the severity of SIJ degeneration. It is well established that age is one of the most critical contributors to the degenerative change in the musculoskeletal system, while it is intriguing that LDH is as important as age in the model (28). Limited studies point out that SIJ degradation is relevant to BMI and gender, but this research did not detect any clue among these issues (12,29).

The association between SIJ degradation and the characteristics of LDH was further evaluated. Recent evidence suggests that multiple operative segments in the lumbar spine significantly increase the risk of postoperative SIJ disorder, compared with a single segment (30). Likewise, a lumbar or lumbosacral fusion of multiple segments raises the incidence of SIJ pain (31).

Despite nearly 70% of patients with LDH only had 1 or 2 herniation levels, we found that SIJ degeneration was more severe in patients with increasing numbers of LDH. This result may be explained by the fact that LDH changed the biomechanical patterns of SIJ behavior. A recent microstructural observation showed stress transduction in patients with LDH was different from normal individuals because of the abnormal interlamellar matrix and lamellae (32). Accompanying with deficiency of lumbar motion in patients with LDH, compensatory movement and stress of SIJ increase, which may cause structural alterations of these joints (33,34).

Upper LDH accounted for less than 3% in all enrolled patients with LDH, which is far less common than LDH at L4-5 and L5-S1. Because our patients with LDH were older compared with previous studies (16), a higher proportion of patients had LDH at L1-2 and/or L2-3. Their score of SIJ degeneration was significantly higher than the other patients with LDH. A possible explanation is that SIJ connects the spine and lower extremities, which are involved in spinopelvic alignment. Upper LDH is related to the change of spinopelvic sagittal alignment, which triggers the degenerative changes of SIJ accordingly (35).

Secondary lumbar stenosis, including spinal canal stenosis, foraminal stenosis, and lateral recess stenosis, is frequently seen in patients with LDH (17). Because the radiographic findings are not always consistent with the symptoms, our enrolled patients with LDH who had LBP clinically fulfilled the criteria of LSS (36). This study revealed the severity of SIJ degeneration was higher in patients with LDH with LSS than the other patients with LDH. Thus far, little is known about the relation between LSS and the alteration of SIJ. Freeman et al (37) showed lumbar stenosis with neurogenic claudication may raise SIJ pain when the patients were walking with a flexed posture, while lumbar decompressive surgery effectively alleviated this disorder. The likely explanation is that LSS leads to alteration of body position and gait, which causes an abnormality of SIJ (38,39).

Sciatica, numbness, and weakness of lower extremes were common manifestations of LDH, therefore this study assessed the relationship between these symptoms and the severity of SIJ degeneration further (40). We found that LDH with sciatica, numbness, and/or weakness suffered from more severe degradation of SIJ. These symptoms attribute to the compression of nerve roots by abnormal intervertebral discs. Furthermore, long-term compression raises the tissue inflammatory process, impairment of intraneural microcirculation, and demyelination of nerve fiber (41). These neurologic deficits may change the gestures by altering muscle strength and the motion of joints, which raises an alteration of SIJ (38,39,42). SLR is widely performed to diagnose LDH with nerve root compression. However, our study did not reveal this physical examination relating to the alteration of SIJ. A possible explanation for this might be that the sensitivity and specificity of SLR are commonly affected by a sequence of factors, such as age, gender, pelvic rotation, and the elasticity and extensibility of the back and hamstring muscles (43,44). CES is a rare but serious neurologic complication of LDH. A previous study demonstrated CES and LDH shared similar prognostic factors, including age, gender, and BMI, which indicated severe CES may relate to more significantly degenerative changes of SIJ (45). Our findings were consistent with this report.

Because the degree of SIJ degeneration linked to the severity of LDH, we attempted to investigate the relevance between SIJ degeneration and the characteristics of patients with LDH. As in the earlier-mentioned results, features, symptoms, and complications of LDH closely related to the severity of SIJ degeneration, which is comparable to age. Intriguingly, the duration of LBP may correlate with SIJ degradation. Previous studies reveal the prolonged duration of symptoms in patients with LDH may relate to poor prognosis and worse therapeutic outcomes (46,47). However, no research concerns the relationship between morphologic changes of SIJ and the duration of LBP in patients with LDH until now.

SIJ is diarthrodial articulations that transmit loads from the upper body to the lower extremities. The previous biomechanical study revealed the pressure generates a high fraction at the articular cartilage surface, which leads to degenerative changes in the long-term (48). LDH decreases the normal lumbar curve and creates muscular stiffness, which considerably promotes the process of SIJ degeneration (49). In other words, LDH is a critical factor related to the degradation of SIJ. Because current clinical studies of invasive treatment for SIJ disorders have displayed mixed results, clinical practitioners must comprehensively consider all relevant patient-associated factors and be cautious in attributing LBP to degenerative changes of SIJ (50,51).

Limitations

Several limitations should be addressed to the present study. First, the main limitation was the ret-

rospective and observational nature. Therefore this study only described the severity of SIJ degeneration was relevant to LDH, whereas the causal relationship was still unclear. By the same token, provocation tests were performed in our clinical practice, but the detailed results were not fully recorded in the electronic medical record system. If future studies combine the radiologic changes and physical examinations of SIJ, a better understanding of the relationship between SIJ degradation and LDH can be provided. Second, MRI is more preferred for LDH and LSS, as this tool provides more accurate details into soft tissues. Nevertheless, the CT scan is still a useful and effective tool because it is enough to present clear bony changes, the main feature of SIJ degeneration, therefore patients may be sent for a CT examination by their family practitioners or outpatient doctors. The lack of an MRI method for SIJ degeneration has been established so far. Also, approximately one-third of patients attended the emergency departments while they were in critical and complex conditions. Because the MRI examination takes a long time, it is necessary to balance the clinical demand and the risk of symptoms relapse when the patients receive this test in the real-world clinical practice (52). This time-consuming radiologic examination may make the emergency rooms more crowded (53). Third, scan parameters of CT examination might be slightly different because of 2 different scanners in 2 centers. However, this might not be of relevance to the objective of our study, and certain quality criteria of CT scan were fulfilled by both centers.

Conclusions

The SIJ degeneration in patients with LDH was more serious than individuals without LDH. Also, SIJ degeneration was more remarkable in patients with LDH with more abnormal features of LDH, symptoms, and complication. Both age and LDH closely link to SIJ degeneration. Consequently, the diagnosis and therapeutic approaches ought to be carefully considered as factors that may contribute to the morphologic change of SIJ.

References

1. Amin RM, Andrade NS, Neuman BJ. Lumbar disc herniation. *Curr Rev Musculoskelet Med* 2017; 10:507-516.
2. DePalma MJ, Ketchum JM, Saullo T. What is the source of chronic low back pain and does age play a role? *Pain Med* 2011; 12:224-233.
3. Schwarzer AC, Aprill CN, Bogduk N. The sacroiliac joint in chronic low back pain. *Spine (Phila Pa 1976)* 1995; 20:31-37.
4. Schneider BJ, Ehsanian R, Rosati R, Huynh L, Levin J, Kennedy DJ. Validity of physical exam maneuvers in the diagnosis of sacroiliac joint pathology. *Pain Med* 2020; 21:255-260.
5. Hilal T, Serkan T, Murat T. The validity and reliability of provocation tests in the diagnosis of sacroiliac joint dysfunction. *Pain Physician* 2018; 21:E367-E376.
6. Ou-Yang DC, York PJ, Kleck CJ, Patel VV. Diagnosis and management of sacroiliac joint dysfunction. *J Bone Joint Surg Am* 2017; 99:2027-2036.
7. Niels H, Benjamin O, Volker F. Sacroiliac joint ligaments and sacroiliac pain: A case-control study on micro- and ultrastructural findings on morphologic alterations. *Pain Physician* 2019; 22:E615-E625.
8. Telli H. Value of examination under fluoroscopy for the assessment of sacroiliac joint dysfunction. *Pain Physician* 2017; 20:E476-E477.
9. Kasliwal PJ, Kasliwal S. Fluoroscopy-guided sacroiliac joint injection: Description of a modified technique. *Pain Physician* 2016; 19:E329-E338.
10. Bäcklund J, Clewett DE, Skorpil M. Is CT indicated in diagnosing sacroiliac joint degeneration? *Clin Radiol* 2017; 72:693.e9-e13.
11. Eno JJ, Boone CR, Bellino MJ, Bishop JA. The prevalence of sacroiliac joint degeneration in asymptomatic adults. *J Bone Joint Surg Am* 2015; 97:932-936.
12. Faflia CP, Prassopoulos PK, Daskalogiannaki ME, Gourtsoyiannis NC. Variation in the appearance of the normal sacroiliac joint on pelvic CT. *Clin Radiol* 1998; 53:742-746.
13. Nikolai B. Commentary on King W, Ahmed S, Baisden J, Patel N, MacVicar J, Kennedy DJ. Diagnosis of posterior sacroiliac complex pain: A systematic review with comprehensive analysis of the published data. *Pain Med* 2015; 16:222-224.
14. Illeez OG, Atıcı A, Ulger EB, Kulcu DG, Ozkan FU, Aktas I. The transitional vertebra and sacroiliac joint dysfunction association. *Eur Spine J* 2018; 27:187-193.
15. de Hooge M, van Gaalen FA, Renson T, et al. Low specificity but high sensitivity of inflammatory back pain criteria in rheumatology settings in Europe: Confirmation of findings from a German cohort study. *Ann Rheum Dis* 2019; 78:1605-1606.
16. Iwasaki M, Akino M, Hida K, et al. Clinical and radiographic characteristics of upper lumbar disc herniation: Ten-year microsurgical experience. *Neurol Med Chir (Tokyo)* 2011; 51:423-426.
17. Andreisek G, Deyo RA, Jarvik JG, et al. Consensus conference on core radiological parameters to describe lumbar stenosis--an initiative for structured reporting. *Eur Radiol* 2014; 24:3224-3232.
18. Haugen AJ, Grøvle L, Brox JI, et al. Estimates of success in patients with sciatica due to lumbar disc herniation depend upon outcome measure. *Eur Spine J* 2011; 20:1669-1675.
19. Radek K, Aneta K, Petr W, Nisaharan S, Michal M, Vladimír B. Are there any risk factors associated with the presence of cauda equina syndrome in symptomatic lumbar disk herniation? *World Neurosurg* 2020; 141:e600-e605.
20. Madani SP, Dadian M, Firouznia K, Alalawi S. Sacroiliac joint dysfunction in patients with herniated lumbar disc: A cross-sectional study. *J Back Musculoskelet Rehabil* 2013; 26:273-278.

21. Shibata Y, Shirai Y, Miyamoto M. The aging process in the sacroiliac joint: Helical computed tomography analysis. *J Orthop Sci* 2002; 7:12-18.
22. Lee YC, Lee R, Harman C. The incidence of new onset sacroiliac joint pain following lumbar fusion. *J Spine Surg* 2019; 5:310-314.
23. Asil K, Yaldiz C. Retrospective assessment of early changes in the sacroiliac joint after posterior lumbar fusion surgery via magnetic resonance imaging and computed tomography. *World Neurosurg* 2018; 120:e546-e550.
24. Nagamoto Y, Iwasaki M, Sakaura H, et al. Sacroiliac joint motion in patients with degenerative lumbar spine disorders. *J Neurosurg Spine* 2015; 23:209-216.
25. Telli H, Hüner B, Kuru Ö. Determination of the prevalence from clinical diagnosis of sacroiliac joint dysfunction in patients with lumbar disc hernia and an evaluation of the effect of this combination on pain and quality of life. *Spine (Phila Pa 1976)* 2020; 45:549-554.
26. Ivanov AA, Kiapour A, Ebraheim NA, Goel V. Lumbar fusion leads to increases in angular motion and stress across sacroiliac joint: A finite element study. *Spine (Phila Pa 1976)* 2009; 34:E162-E169.
27. Arnau J, Bono R, Blanca MJ, Bendayan R. Using the linear mixed model to analyze nonnormal data distributions in longitudinal designs. *Behav Res Methods* 2012; 44:1224-1238.
28. Badley EM, Wilfong JM, Yip C, Millstone DB, Perruccio AV. The contribution of age and obesity to the number of painful joint sites in individuals reporting osteoarthritis: A population-based study. *Rheumatology (Oxford)* 2020;59:3350-3357.
29. Lindsey RW. Sacroiliac joint degeneration: forgiving, but not to be forgotten: Commentary on an article by Jonathan-James T. Eno, MD, et al.: "The prevalence of sacroiliac joint degeneration in asymptomatic adults". *J Bone Joint Surg Am* 2015; 97:e50.
30. Guan F, Sun Y, Zhu L, et al. Risk factors of postoperative sacroiliac joint pain for posterior lumbar surgery: ≥2-Year follow-up retrospective study. *World Neurosurg* 2018; 110:e546-e551.
31. Unoki E, Abe E, Murai H, Kobayashi T, Abe T. Fusion of multiple segments can increase the incidence of sacroiliac joint pain after lumbar or lumbosacral fusion. *Spine (Phila Pa 1976)* 2016; 41:999-1005.
32. Tavakoli J, Amin DB, Freeman BJC, Costi JJ. The biomechanics of the inter-lamellar matrix and the lamellae during progression to lumbar disc herniation: Which is the weakest structure? *Ann Biomed Eng* 2018; 46:1280-1291.
33. Kuai S, Zhou W, Liao Z, et al. Influences of lumbar disc herniation on the kinematics in multi-segmental spine, pelvis, and lower extremities during five activities of daily living. *BMC Musculoskelet Disord* 2017; 18:216.
34. Ha KY, Lee JS, Kim KW. Degeneration of sacroiliac joint after instrumented lumbar or lumbosacral fusion: A prospective cohort study over five-year follow-up. *Spine (Phila Pa 1976)* 2008; 33:1192-1198.
35. Bae J, Lee SH, Shin SH, Seo JS, Kim KH, Jang JS. Radiological analysis of upper lumbar disc herniation and spinopelvic sagittal alignment. *Eur Spine J* 2016; 25:1382-1388.
36. AM, Torralba KD. Lumbar spinal stenosis in older adults. *Rheum Dis Clin North Am* 2018; 44:501-512.
37. Freeman TB, Bach K, Murtagh RD. Influence of lumbar stenosis surgery on sacroiliac joint pain—long term results. *World Neurosurg* 2020; 136:e386-e392.
38. Goto T, Sakai T, Enishi T, et al. Changes of posture and muscle activities in the trunk and legs during walking in patients with lumbar spinal stenosis after decompression surgery. A preliminary report. *Gait Posture* 2017; 51:149-152.
39. Schomacher M, Kunhardt O, Koeppen D, et al. Transient sacroiliac joint-related pain is a common problem following lumbar decompressive surgery without instrumentation. *Clin Neurol Neurosurg* 2015; 139:81-85.
40. Wang Y, Gao F, Zou H. Numbness and weakness recovered at a less extent in patients with lumbar disc herniation after percutaneous endoscopic lumbar discectomy. *Pain Res Manag* 2019; 2019:4642701.
41. Nunes RC, Pontes ER, Costa IP. Evaluation of epidural blockade as therapy for patients with sciatica secondary to lumbar disc herniation. *Rev Bras Ortop* 2016; 51:424-430.
42. Chen LC, Kuo CW, Hsu HH, Chang ST, Ni SM, Ho CW. Concurrent measurement of isokinetic muscle strength of the trunk, knees, and ankles in patients with lumbar disc herniation with sciatica. *Spine (Phila Pa 1976)* 2010; 35:E1612-E1618.
43. Tabesh H, Tabesh A, Fakharian E, Fazel M, Abrishamkar S. The effect of age on result of straight leg raising test in patients suffering lumbar disc herniation and sciatica. *J Res Med Sci* 2015; 20:150-153.
44. Majlesi J, Togay H, Unalan H, Toprak S. The sensitivity and specificity of the slump and the straight leg raising tests in patients with lumbar disc herniation. *J Clin Rheumatol* 2008; 14:87-91.
45. Grasso G, Munakomi S, Sallì M. Red flag for cauda equina syndrome in symptomatic lumbar disc herniation. *World Neurosurg* 2020; 143:232-234.
46. Støttrup CC, Andresen AK, Carreon L, Andersen MØ. Increasing reoperation rates and inferior outcome with prolonged symptom duration in lumbar disc herniation surgery--A prospective cohort study. *Spine J* 2019; 19:1463-1469.
47. Wu W, Liang J, Ru N, et al. Microstructural changes in compressed nerve roots are consistent with clinical symptoms and symptom duration in patients with lumbar disc herniation. *Spine (Phila Pa 1976)* 2016; 41:E661-E666.
48. Vleeming A, Schuenke MD, Masi AT, Carreiro JE, Danneels L, Willard FH. The sacroiliac joint: An overview of its anatomy, function and potential clinical implications. *J Anat* 2012; 221:537-567.
49. Jeong DK, Choi HH, Kang J, Choi H. Effect of lumbar stabilization exercise on disc herniation index, sacral angle, and functional improvement in patients with lumbar disc herniation. *J Phys Ther Sci* 2017; 29:2121-2125.
50. Ibrahim R, Telfeian AE, Gohlke K, Decker O. Endoscopic radiofrequency treatment of the sacroiliac joint complex for low back pain: A prospective study with a 2-year follow-up. *Pain Physician* 2019; 22:E111-E118.
51. Kennedy DJ, Engel A, Kreiner DS, Nampiaparampil D, Duszynski B, MacVicar J. Fluoroscopically guided diagnostic and therapeutic intra-articular sacroiliac joint injections: A systematic review. *Pain Med* 2015; 16:1500-1518.
52. Milburn JA, Bailey JA, Dunn WK, Cameron IC, Gomez DS. Inpatient magnetic resonance cholangiopancreatography: Does it increase the efficiency in emergency hepatopancreaticobiliary surgery services? *Ann R Coll Surg Engl* 2017; 99:289-294.
53. Memoona M, Faisal K, Ismail TA, et al. Faster magnetic resonance imaging in emergency room patients with right lower quadrant pain and suspected acute appendicitis. *Pol J Radiol* 2018; 83:e340-e347.