

Clinical Study

Disc height discrepancy between supine and standing positions as a screening metric for discogenic back pain in patients with disc degeneration

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Abstract

BACKGROUND CONTEXT: The diagnosis of discogenic low back pain (LBP) from disc degeneration of the lumbar spine is often evaluated with discography. Noninvasive, simple screening methods other than invasive discography are useful, as evidence supporting clinical findings and magnetic resonance imaging (MRI) have come to the forefront.

PURPOSE: To investigate disc height (DH) discrepancy between supine and standing positions on simple radiography to clarify its clinical screening value in individuals with discogenic LBP.

STUDY DESIGN/SETTINGS: Retrospective matched cohort design.

PATIENT SAMPLE: Ninety-two patients with early to middle stage disc degeneration (Pfirrmann grade II, III, or IV).

OUTCOME MEASURES: Each subject underwent simple radiographs and MRI. Baseline characteristics, including demographic data and MRI findings, and radiological findings, including DH discrepancy, segmental angle, and sagittal balance, were analyzed. DH discrepancy ratio was calculated as $(1 - [\text{calibrated DH on standing radiography} / \text{calibrated DH on supine radiography}]) \times 100\%$.

METHODS: We matched LBP group of 46 patients with intractable discogenic pain (≥ 7 of visual analog scale scores) confirmed by discography with control group of 46 patients with similar stage disc degeneration with mild LBP (≤ 4 of visual analog scale scores). Binary regression analysis, receiver operating characteristic curve analysis, and cut-off value for diagnosis were used to evaluate and clarify diagnostic value of various factors.

RESULTS: There was no significant difference between the two groups in terms of baseline characteristics, including age, sex, body mass index, pathological level, and magnetic resonance findings such as disc degeneration, high intensity zone, and para-spinal muscle volume.

Among the various radiological findings, the calibrated mean DH in the standing position (20.87 ± 5.65 [LBP group] vs. 26.95 ± 3.02 [control group], $p < .001$) and the DH discrepancy ratio ($14.55 \pm 6.13\%$ [LBP group] vs. $1.47 \pm 0.75\%$ [control group], $p = .007$) were significantly different between the two groups. The cut-off value for DH discrepancy ratio to screen discogenic LBP was $\geq 6.04\%$.

Additionally, as a compensation for pain, sagittal vertical axis (3.43 ± 2.03 cm [LBP group] vs. -0.54 ± 3.05 cm [control group], $p = .002$) and pelvic incidence ($54.74 \pm 6.76^\circ$ [LBP group] vs. $43.98 \pm 8.67^\circ$ [control group]; $p = .006$) were different between the two groups.

CONCLUSIONS: The results suggest that DH discrepancy between the supine and standing positions could be a screening metric for discogenic LBP in early to middle stage disc degeneration of the lumbar spine. © 2020 Elsevier Inc. All rights reserved.

Key words: Disc degeneration; Disc height; Intervertebral disc; Low back pain

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Introduction

Low back pain (LBP) has a prevalence of $\geq 30\%$ and a lifetime prevalence of 60% to 80% [1]. It is a major clinical problem in patients with spinal diseases and contributes to the socioeconomic health burden worldwide [2]. Although 60% to 70% of LBP is nonspecific without obvious origin, intervertebral disc degeneration or internal disruption have been considered to be the major causes, with a prevalence of 26% to 42% among patients with LBP [3,4]. Discogenic LBP, which is believed to originate from disc degeneration without definite disc herniation, instability, spondylolisthesis, or deformity, is difficult to define and diagnose because it can be associated with multifactorial conditions such as facet joint degeneration, para-spinal muscle problem, or various ligament strains [5–8].

Conventional magnetic resonance imaging (MRI) is a widely used qualitative or semiquantitative noninvasive modality to evaluate the morphology and water content of the intervertebral discs [9]. Currently, however, the specificity or sensitivity of the Pfirrmann grade according to MRI is not sufficient to confirm a diagnosis of discogenic LBP and has demonstrated insufficient effectiveness in fully identifying sources of LBP in those with disc degeneration [10–12]. In other words, even with similar stage disc degeneration on MRI, pathogenic disc degeneration can cause severe LBP whereas simple disc degeneration due to aging process does not cause severe LBP. Therefore, the detection of discogenic LBP among patients with disc degeneration on MRI is a clinically challenging task.

To overcome difficulties and controversies surrounding the diagnosis of discogenic LBP, some have proposed provocative discography and discography computed tomography (CT) for the diagnosis of discogenic LBP due to disc degeneration [7,13,14]. However, reports have indicated that disc degeneration or disc herniation can be accelerated after discography, and discography can have a high false-positive rate [15]. Accordingly, the clinical use of discography should be limited in patient selection to discriminate surgical indication as a confirmatory procedure rather than as an early diagnostic screening tool [4,16].

Therefore, noninvasive, simple screening diagnostic methods other than invasive discography are necessary, as evidence supporting clinical findings and MRI, for diagnosis of discogenic LBP. Several previous studies have demonstrated that reduced disc height (DH) is correlated with disc degeneration in the lumbar spine, and further, decreases in DH and LBP are aggravated by axial loading in patients with disc degeneration [17–20]. Based on this concept, in patients with early to middle stage disc degeneration (i.e., Pfirrmann grade II, III, or IV), there may be a difference in DH according to posture dynamics between those with clinically significant discogenic LBP and those without significant pain.

In this study, we compared radiological findings, particularly DH discrepancy between the supine and standing positions, between patients with significant discogenic LBP confirmed by discography and those with similar stage disc degeneration without severe LBP. To the best of our knowledge, the present study is the first to compare the DH discrepancy of discogenic LBP with those of simple disc degeneration using a retrospective matched cohort design.

Materials and methods

Patient selection

The study was approved by the Institutional Review Board of our institute (GFIRB2020-107). A retrospective chart review was performed on all patients who underwent MRI with or without discography for diagnosis of discogenic LBP at a single institution between January 2010 and December 2019. Given the retrospective nature of the study and the use of anonymized patient data, requirements for informed consent were waived.

Indications for lumbar discography were as follows: (1) persistent severe LBP (≥ 7 of visual analog scale (VAS) scores) without significant radiating leg pain despite adequate sufficient conservative treatment at least 3 months; (2) no definite reason for LBP except disc degeneration in clinical survey and imaging study, such as extruded disc (not bulging or protruded), segmental instability, spondylolisthesis, compression fracture, cancer pain, or infectious disease; and (3) no surgical contraindication, such as history of allergic reaction to contrast agent, pregnancy, suspected infectious disease, hematological coagulation disorder, or renal failure.

Discography was performed by three surgeons at a single institute. Discogenic LBP was defined as similar severe LBP provoked by injection of 0.5 to 2.0 cc of 1:1 mixture of normal saline and contrast agent in the suspected level, with correlated demonstration of annular tear or leakage of contrast agent on postoperative CT [21].

The study inclusion criteria were as follows: (1) single level pathogenic disc degeneration confirmed by discography; (2) early to middle stage disc degeneration on MRI (Pfirrmann grade II, III, or IV) [9]; and (3) no history of surgery on the lumbar spine. To minimize selection bias, individuals without aggravated LBP during discography or correlated picture of postoperative CT, those with advanced disc degeneration (Pfirrmann grade V), and those with multilevel pathogenic disc degeneration were excluded from the study.

Among the 78 patients who underwent discography, 32 were excluded for the following reasons: presence of multilevel pathogenic disc degeneration ($n=13$); advanced disc degeneration (Pfirrmann grade V) on MRI ($n=10$); history of surgery ($n=5$); no provocation or equivocal findings after

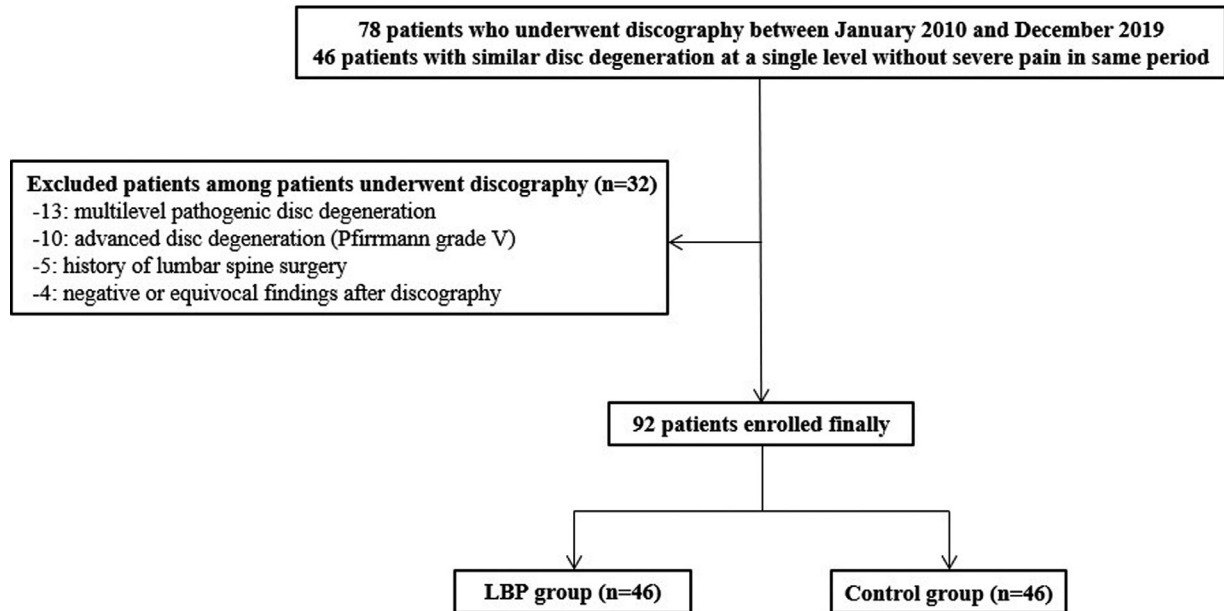


Fig. 1. Patient selection.

discography (n=4). The remaining 46 patients were enrolled as the final study cohort.

The control group consisted of age- and sex-matched patients who suffered from mild LBP (≤ 4 of VAS scores) improved after conservative treatment and underwent MRI to evaluate the condition of lumbar spine. Among them, the 46 patients with early to middle stage disc degeneration at a single level on MRI (Pfirrmann grade II, III, or IV) were selected.

The final total cohort, therefore, was divided into two groups: a LBP group, with intractable discogenic pain confirmed by discography (n=46), and a control group, with similar stage disc degeneration without severe LBP (n=46) (Fig. 1).

Demographic information and baseline characteristics

Demographic information, including age, sex, height, weight, and body mass index, was collected. Additionally, the degree of pain was assessed using visual analog scale (VAS) scores for LBP and leg pain.

Baseline characteristics affecting clinical symptoms on MRI, including level of pathological disc degeneration, degree of disc degeneration, end plate degeneration, degree of end plate sclerosis, high intensity zone, type of disc herniation (bulging or protrusion), and facet joint degeneration, were evaluated. Disc degeneration according to Pfirrmann grade was defined as follows: grade I, homogenous bright white nucleus pulposus; grade II, inhomogenous nucleus pulposus with maintained disc space; grade III, grey nucleus pulposus with slightly decreased disc space; grade IV, grey to black disc with unclear distinction of nucleus and annulus and moderate decreased disc space; and grade V, black disc with collapsed disc space [9]. The degree of

degeneration of adjacent end plate according to Modic change was defined as follows: type 0, no definite signal change in end plate; type I, high signal intensity on T2-weighted image and low signal intensity on T1-weighted image; type II, high signal intensity on both T2-weighted image and T1-weighted image; and type III, low signal intensity on both T2 and T1 weighted image [22]. Degree of end plate sclerosis was defined as follows: grade 0, no end plate defect; grade I, focal end plate defect; grade II, anterior or posterior corner defects; and grade III; erosive diffuse defect [12]. High intensity zone was defined as high signal change of posterior annulus on T2-weighted image implying annular tear [23]. Facet joint degeneration was defined as follows: grade 0, normal facet joint; grade I, narrowing of the facet joint with mild hypertrophy or osteophyte; grade II, moderate hypertrophy or osteophyte with moderate erosions; and grade III, severe hypertrophy or osteophyte with severe bone erosions [24].

To preclude the effect of the paraspinal muscle on LBP, fat infiltration in the multifidus muscle and the cross-sectional area of the paraspinal muscles, such as the psoas, multifidus, spinae erector including the longissimus and iliocostalis lumborum, and quadratus, were evaluated. Fat infiltration of multifidus muscle was defined as follows: grade I, $\leq 10\%$ fat infiltration; grade II, 10% to 50% fat infiltration; and grade 3, $\geq 50\%$ fat infiltration [25]. The cross-sectional area of the paraspinal muscles was calculated as the product of long axis and short axis perpendicular to it.

Simple radiography

Simple radiographs in supine and standing position were obtained consequently after clinical examination during the daytime (between 9 AM and 5 PM).

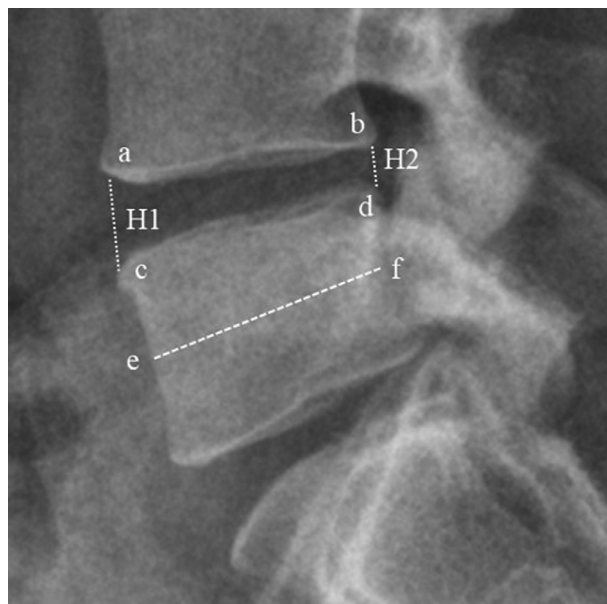


Fig. 2. Measurement of the intervertebral disc height. Average disc height = $[H1 \text{ (mm)} + H2 \text{ (mm)}] / 2$, Calibrated average disc height = $[Average \text{ DH (mm)} / \text{anteroposterior diameter of L5 body (mm)}] \times 100$. (a): antero-inferior corner of the superior vertebra, (b): postero-inferior corner of the superior vertebra, (c): anterosuperior corner of the inferior vertebra, (d): posterosuperior corner of the inferior vertebra, (e): anterior middle border of the L5 body, (f): posterior middle border of the L5 body.

Average DH was obtained from the average of anterior and posterior DHs at the pathological level in the supine and standing positions, respectively. The average DH was then calibrated with the anteroposterior diameter of the L5 body to eliminate fluctuating magnification effect of X-ray as:

$$[\text{Average DH (mm)} / \text{anteroposterior diameter of L5 body (mm)}] \times 100 \text{ (Fig. 2)}.$$

Finally, the DH discrepancy ratio was calculated as:

$$(1 - [\text{calibrated DH on standing} / \text{calibrated DH on supine}]) \times 100 \text{ \%}.$$

The segmental angle of the pathological level in the neutral supine position and range of motion of pathological level using flexion/extension radiography on supine radiography were analyzed. Additionally, to clarify sagittal balance, parameters including lumbar lordosis, sagittal vertical axis, sacral slope, pelvic tilt, and pelvic incidence were evaluated in the neutral standing position.

Assessment of MRI and simple radiograph were performed by two researchers who were blinded to group allocation. Each observer measured the same image twice for all parameters. If there was any disagreement about qualitative parameters between the researchers, a conclusion was reached by consensus discussion. The quantitative parameter was determined as the average result of the two researchers.

Statistical analysis

Data management and statistical analysis were performed using SPSS version 23.0 (IBM Corporation, Armonk, NY, USA). Cohen's kappa and Intraclass coefficient correlation (ICC) were used to prove both intra- and interobserver reproducibility. Pearson's chi square test, independent *t* test, and nonparametric Mann-Whitney *U* test were used according to characteristics of the factors. Additionally, binary regression analysis, receiver operating characteristic (ROC) curve analysis, and cut-off value for diagnosis using cross-graph analysis were used to evaluate and clarify diagnostic value of various factors. Results are expressed as mean $\pm$ standard deviation or mean and corresponding 95% confidence interval (CI), depending on whether the data were normally distributed. Differences with $p < .05$ were considered statistically significant.

Results

Demographic information and baseline characteristics

No significant difference was observed between the LBP and control groups in terms of demographic data and symptom-related baseline characteristics, except for VAS back. As expected, VAS back was significantly different between the two groups (7.61 [95% CI, 7.03–8.19] in the LBP group vs. 2.72 [95% CI, 2.44–3.01] in the control group, $p < .001$, nonparametric Mann-Whitney *U* test) (Table 1).

The measurements of MRI findings had high intra- and interobserver reliability ranging between 0.922 and 0.975 for qualitative measures based on Cohen's kappa and between 0.841 and 0.952 for quantitative measures based on ICC. There were no differences in MRI findings, including pathological disc level, disc degeneration, end plate degeneration, high intensity zone, type of disc herniation (bulging or protrusion), facet joint degeneration, fat infiltration in the multifidus muscle, and cross-sectional area of paraspinal muscles, between the two groups (Table 2).

Simple radiography findings

Our assessments of simple radiograph were highly reproducible with excellent intra- and interobserver agreement between two raters. ICC ranged from 0.954 to 0.988 for disc height and 0.925 to 0.982 for variables related to sagittal balance.

Interestingly, the calibrated mean DH in the standing position was significantly different between the groups (20.87 ± 5.65 in the LBP group vs. 26.95 ± 3.02 in the control group, $p < .001$, independent *t* test) despite a nonsignificant difference in the supine position (24.98 ± 6.17 in the LBP group vs. 27.46 ± 3.37 in the control group, $p = .838$, independent *t* test). Accordingly, the DH discrepancy ratio was significantly different between the two groups ($14.55 \pm 6.13\%$ in the LBP group vs. $1.47 \pm 0.75\%$ in the control group, $p = .001$, independent *t* test). In other words,

Table 1
Baseline characteristics

	LBP group (n=46)	Control group (n=46)	p Value
Age (years)	40.8±9.0	35.5±10.0	.083*
Sex (male/female)	22/24	23/23	.870 [†]
Height (cm)	170.45±8.65	168.45±7.79	.568*
Weight (kg)	68.41±22.68	66.13±15.56	.783*
Body mass index (kg/m ²)	23.23±7.12	23.06±3.62	.945*
Visual analog scale, back	7.61 (95% CI, 7.03–8.19)	2.72 (95% CI, 2.44–3.01)	<.001 [‡]
Visual analog scale, leg	2.22 (95% CI, 1.83–2.61)	2.06 (95% CI, 1.66–2.46)	.620 [‡]

Data presented as mean ± standard deviation, n/n, or mean (95% confidence interval [CI]) unless otherwise indicated.

LBP, low back pain.

* Independent *t* test.

[†] Pearson's Chi square test.

[‡] Nonparametric Mann-Whitney *U* test.

DH was decreased in the standing position compared with the supine position in both groups; however DH discrepancy between the supine and standing positions was more significant in the LBP group than in the control group (Table 3).

There was no significant difference in segmental angle of index level, range of motion of index level, lumbar lordosis, and sacral slope. Sagittal vertical axis (3.43±2.03 cm in the LBP group vs. −0.54±3.05 cm in the control group, *p*<.001, independent *t* test), pelvic incidence (54.74±6.76° in the LBP group vs. 43.98±8.67° in the control group, *p*=.006), and pelvic tilt (18.16±9.73° in the LBP group vs. 10.91±7.60° in the control group, *p*=.030, independent *t* test) were significantly different between the two groups. In other words, the LBP group showed more forward-bended sagittal balance and/or pelvic retroversion than the control group (Table 3).

Evaluation of diagnostic value

According to binary logistic regression analysis of various factors with *p*<.2 (DH discrepancy ratio, range of motion, sagittal vertical axis, pelvic tilt, and pelvic incidence), statistically significant factors affecting diagnosis of discogenic LBP included DH discrepancy ratio (odds ratio 1.467 [95% CI, 1.030–2.088], *p*=.034), sagittal vertical axis (odds ratio 1.815 [95% CI, 1.075–3.188], *p*=.026), and pelvic incidence (odds ratio 1.192 [95% CI, 1.004–2.035], *p*=.041) (Table 4).

According to ROC curve analysis, for discogenic LBP, the diagnostic value of DH discrepancy ratio, sagittal vertical axis, and pelvic incidence were significant (area under the ROC curves 0.822, 0.875, and 0.803, respectively) (Fig. 3). Furthermore, according to cross-graph analysis from ROC data, the cut-off value for DH discrepancy ratio

Table 2
Baseline characteristics of magnetic resonance imaging findings

	LBP group (n=46)	Control group (n=46)	p Value
Level (L2–3/L3–4/L4–5/L5–S1)	2/4/18/22	4/12/16/16	.210 [†]
Pfirsman grade (I/II/III/IV/V)	0/2/32/12/0	0/3/36/7/0	.722*
Modic change (0/I/II/III)	30/12/2/2	35/9/1/1	.479*
End plate degeneration (0/I/II/III)	38/8/0/0	42/4/0/0	.700*
High intensity zone	9 (19.57%)	4 (8.70%)	.262*
Bulging/protrusion/extrusion	19/27/0	33/13/0	.106*
Facet joint degeneration (I/II/III)	13/30/3	10/36/0	.425*
Fat infiltration of multifidus (0/I/II/III)	7/30/9/0	11/29/6/0	.692*
Right psoas (mm ²)	432.83±219.91	395.84±182.41	.664 [†]
Right spine erector (mm ²)	1063.71±271.14	1072.10±287.09	.943 [†]
Right multifidus (mm ²)	266.61±79.70	259.40±50.62	.796 [†]
Right quadratus (mm ²)	254.49±129.58	238.53±98.31	.403 [†]
Left psoas (mm ²)	412.73±207.85	456.02±247.00	.655 [†]
Left spine erector (mm ²)	988.67±363.15	991.70±262.60	.982 [†]
Left multifidus (mm ²)	221.20±63.18	228.09±50.38	.774 [†]
Left quadratus (mm ²)	225.90±86.60	232.26±99.61	.872 [†]

Data presented as n or mean ± standard deviation, unless otherwise indicated.

LBP, low back pain.

* Pearson's Chi square test.

[†] Independent *t* test.

Table 3
Simple radiography findings

	LBP group (n=46)	Control group (n=46)	p Value
Average DH supine, calibrated	24.98±6.17	27.46±3.37	.838*
Average DH standing, calibrated	20.87±5.65	26.95±3.02	<.001*
DH standing/supine (%)	85.55±6.13	98.53±0.75	.001*
DH discrepancy ratio (%)	14.55±6.13	1.47±0.75	.001*
Segmental angle (°)	7.32±6.20	7.61±4.09	.869*
Range of motion (°)	9.64±5.04	11.82±3.90	.170*
Lumbar lordosis (°)	42.50±11.09	40.37±1.28	.773*
Sagittal vertical axis (cm)	3.43±2.03	−0.54±3.05	<.00*
Pelvic incidence (°)	54.74±6.76	43.98±8.67	.006*
Sacral slope (°)	36.58±5.93	33.07±9.14	.250*
Pelvic tilt (°)	18.16±9.73	10.91±7.60	.030*

Data presented as mean ± standard deviation, unless otherwise indicated.

DH, disc height; LBP, low back pain.

* Independent *t* test.

Table 4
Binary regression analysis for LBP group versus control group

	B	Odds ratio	p Value
DH discrepancy ratio (%)		1.467 (95% CI, 1.030–2.088)	.034
Sagittal vertical axis (cm)		1.851 (95% CI, 1.075–3.188)	.026
Pelvic incidence (°)		1.192 (95% CI, 1.004–2.035)	.041
Range of motion (°)			.457
Pelvic tilt (°)			.214
Constant	−4.817	0.008	.016

DH, disc height; LBP, low back pain.

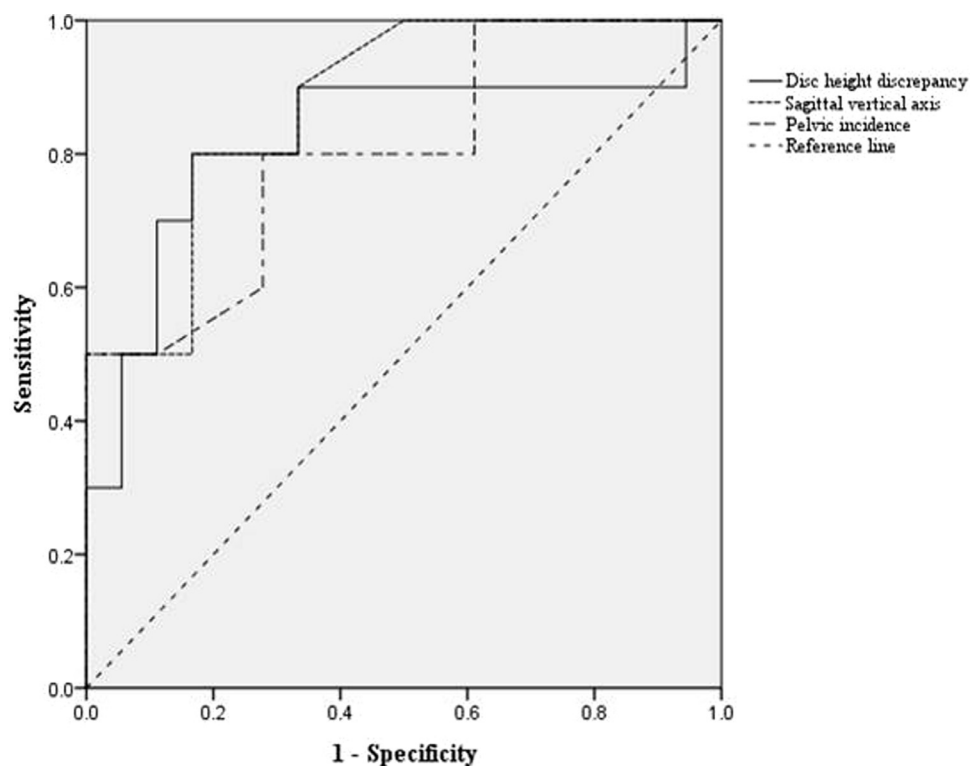


Fig. 3. Receiver operating characteristic (ROC) curve for disc height discrepancy ratio, sagittal vertical axis, and pelvic incidence. The areas under the ROC curve were 0.822, 0.875, and 0.803, respectively.

for diagnosis of discogenic LBP was $\geq 6.04\%$, with a sensitivity of 0.800 and a specificity of 0.834. Additionally, the cut-off value for sagittal vertical axis for diagnosis of discogenic LBP was ≥ 1.77 cm, with a sensitivity of 0.800 and a specificity of 0.834; the cut-off value for pelvic incidence for diagnosis of discogenic LBP was $\geq 47.15^\circ$, with a sensitivity of 0.800 and a specificity of 0.722.

Discussion

DH is known to be related to disc degeneration, and disc space narrowing has been recognized as a characteristic of disc degeneration [26,27]. Accordingly, DH measurement has been used to quantitatively assess disc degeneration, and the degree of DH decrease may reflect the degree of disc degeneration [19]. Moreover, axial loading of the lumbar spine causes buckling of the spinal motion unit, including disc space and ligaments, and results in a decrease in DH even in the same patient [17,28]. Based on these concepts, we presumed that DH discrepancy between the supine position without axial loading and the standing position with axial loading of gravity is a natural finding in virtually all patients.

We speculated that the degree of DH discrepancy between the supine and standing positions may be exaggerated in patients with pathogenic disc degeneration because of progressive structural failure and decreases in the elasticity of the nucleus due to biochemical reactions, which is different from usual disc degeneration due to the aging process [29,30]. It is likely that DH discrepancy is minimized in healthy discs due to maintenance of structural function, and in advanced disc degeneration, because of nearly fused segments or nearly collapsed disc space. However, the degree of DH discrepancy may be enhanced in patients with early to middle stage disc degeneration on MRI (i.e. Pfirrmann grade II, III, or IV) combined with clinically significant discogenic LBP compared to patients with similar stage disc degeneration on MRI without significant discogenic LBP. To confirm of this assumption and to evaluate the diagnostic value of DH discrepancy for screening discogenic LBP among patients with early to middle stage disc degeneration, we compared radiological findings between the patients with discogenic LBP proved by discography and the patients of similar stage disc degeneration without significant discogenic LBP.

In our study, baseline characteristics, including age, body mass index, VAS leg, pathological level, degenerative change of various anatomical structures on MRI, and findings of paraspinal muscle on MRI, were not different between the two groups. However, patients in the LBP group who underwent discography for diagnosis exhibited more severe VAS back scores than the control group. This difference implies that the LBP group was more clinically severe than the control group in terms of back pain despite similar degree of disc degeneration and baseline characteristics.

DH discrepancy ratio was more significant in the LBP group than in the control group, and its cut-off value for differential diagnosis between pathogenic disc degeneration with discogenic LBP and usual disc degeneration without significant LBP was $\geq 6.04\%$. In other words, if the DH discrepancy ratio is $\geq 6.04\%$ in patients with early to middle stage disc degeneration, we can suspect significant discogenic LBP.

Previous studies have suggested that the axial load through vertical axis potentially affects postural change as well as parameters of the sagittal alignment including sagittal vertical axis and lumbar lordosis [28,31–35]. According to our results, although other parameters of sagittal alignment were not different, sagittal vertical axis and pelvic incidence were significantly different between the two groups. In other words, the global posture of sagittal balance bent forward and the pelvis exhibited retroversion in the LBP group compared with the control group despite similar baseline characteristics.

It remains unclear which emerges first: early to middle stage disc degeneration or postural change (forward-bent and/or pelvic retroversion) precedes first. However, we speculate that increase of sagittal vertical axis and pelvic incidence were caused by severe discogenic LBP originated from disc degeneration. If increase of sagittal vertical axis and pelvic incidence were the precedent phenomenon, other sagittal parameters including pelvic tilt, sacral slope, and lumbar lordosis also should be different between the two groups. Additionally, if postural change was the precedent phenomenon, pelvic incidence should be similar despite a different sagittal vertical axis because the baseline characteristics that can affect pelvic incidence, including age, sex, degree of degenerative change, and status of paraspinal muscles, were similar between the two groups. In other words, because the sagittal balance was changed to forward-bent posture and/or pelvic retroversion to compensate for discogenic LBP, sagittal vertical axis and pelvic incidence may increase in conjunction.

Although sagittal vertical axis and pelvic incidence were different between discogenic LBP group and control group, the difference were not clearly distinguished unlike changes by other degenerative conditions, such as aging process, sarcopenia, or spinal deformity. Additionally, measurement consistency and reliability depend on different situation of same patient are also questionable because the change of sagittal parameter is not a leading factor but a natural compensating course of discogenic LBP. Finally, only the DH discrepancy is the potential diagnostic screening tool to detect clinically significant discogenic LBP in patients with early to middle stage disc degeneration on MRI.

Based on multifactorial viewpoints, including clinical symptom, imaging study, and discography, the differentiation between pathogenic disc degeneration and simple disc degeneration due to aging process is important because proper patient selection is a mandatory step for successful treatment or surgery. However, unfortunately, diagnostic

tool to confirm pathogenic disc degeneration is controversial yet and confused even to specialist. Our screening metric based on simple radiographic findings may help overcoming diagnostic confusion of pathogenic disc degeneration axillary to existing methods. For example, if the patient with severe persistent LBP has significant disc height discrepancy on simple radiograph, we may doubt pathogenic disc degeneration, and perform further investigation or treatment. On the contrary, if the patient with mild to moderate LBP has nonsignificant disc height discrepancy, we may find another reason for LBP rather than disc degeneration. As shown in statistical results, false positive or false negative finding can occur, but this noninvasive screening method could enhance the diagnostic power of clinician as an auxiliary tool.

The present study had some limitations. Patient's life style, including hours of sleep and waking time, physical activity, such as, consistent position, existing preload, and vibratory loads, and diurnal variation, can affect DH owing to creep deformation of the disc [28,36]. Due to the retrospective design of the present study, it was impossible to control for all variations. Moreover, the number of patients in the final cohort was insufficient to conclude diagnostic value, and the statistical significance of values would be lower in an external validation sample. However, to our knowledge, this study was the first to emphasize the DH discrepancy ratio between supine and standing radiography as a screening metric in discogenic LBP due to disc degeneration. Prospective mechanical and experimental studies with strict control of conditions or more complete studies with a larger number of subjects are required to confirm our results.

Conclusion

According to the results, DH discrepancy ratio between supine and standing simple radiography, sagittal vertical axis, and pelvic incidence were significantly different between the two groups. In particular, as a supplement to discography, DH discrepancy ratio could have diagnostic screening value for discogenic LBP in individuals with early to middle stage disc degeneration on lumbar MRI.

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