Degenerative Disk Disease at Lumbosacral Junction: Plain Film Findings and Related MRI Abnormalities

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Abstract

Due to a wide range of normal disk space heights at lumbosacral (LS) junction, we conducted this study to evaluate how to diagnose degenerative disk disease (DDD) of LS junction and how much information we can obtain from plain radiography regarding this condition. We retrospectively reviewed lateral LS spine films and magnetic resonance (MR) imaging in 100 patients presented with low back pain. Anterior disk height (ADH) and posterior disk height (PDH) were directly measured from plain radiographs. Signs of DDD were recorded from both plain radiographs and MR imaging. We found that ADH < 11.3 mm or PDH < 5.5 mm indicate DDD at LS junction with 95 per cent confidence interval. When spondylolisthesis presented, disks were all degenerated. Endplate sclerosis had significant relative risk ($p < 0.05$) for lateral neural canal stenosis and disk herniation. No radiographic finding showed significant relative risk for nerve root compression.

Key word : Spine, Intervertebral Disk, Spine, MR

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Degenerative change of intervertebral disk complex is a common finding in asymptomatic patients[1-3], and was found to begin early in life [4-7]. By the age of 50, 85-95 per cent of adults show evidence of degenerative disk disease (DDD) at autopsy[7-9]. Plain films of lumbosacral (LS) spine are routinely obtained on many patients to evaluate DDD as a cause of low back pain. It is known that DDD can occur without a loss of disk height[10] and when the plain film appears normal.

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In general, a disk is considered abnormal on plain film if its height is less than that of the disk above ; however, at the LS junction the disk space can be smaller than the disk space immediately superior to it and is still normal[11]. We observed this similarity in our Thai population compared to the study of other ethnic groups[11].

We conducted this study to evaluate 1] whether the disk height of LS junction on plain film can indicate DDD, and 2] if any finding on plain film regarding a DDD of LS junction has relation with findings in corresponding magnetic resonance (MR) imaging. Since MR imaging has been proved to be highly sensitive in demonstrating DDD[1,7,8,10-23], we, therefore, used it as the reference standard in this study.

MATERIAL AND METHOD

Matched lateral LS spine film and MR imaging in 100 patients presented with low back pain, performed not more than 2 months apart, were retrospectively reviewed. The plain films were obtained at a film-screen distance of 40 inches, using phototimer technique. The center was on the iliac crest. The film was taken on lateral position, straightening the hip. The anterior disk height (ADH) and posterior disk height (PDH) were directly measured (Fig. 1) and magnification factor of 1.4 was corrected. The mean value with 95 per cent confidence interval (CI) was calculated for each measurement. Findings of DDD on plain film i.e., end plate sclerosis, osteophyte, and spondylolisthesis of the LS junction were recorded. *Endplate sclerosis* was considered when there was a continuous dense line $\geq$ 1 mm thick along the inferior endplate of L5 or superior endplate of S1 or both. *Osteophyte* defined as a prominent bone proliferation along the anterior and lateral aspect of vertebral body. *Spondylolisthesis* referred to displacement of one vertebra on another[24].

MR imaging was performed with a 1.5-T unit (General Electric, Milwaukee, WI) with a phase-array coil. The T2-weighted sagittal images were used for review. The intervertebral disk was classified in MR imaging into 3 types according to Yu et al[25]. *Normal disk* showed a moderately high signal from nucleus and anulus, low signal from Sharpey fibers and fibrous tissue in the mid portion of the disk. *Mildly degenerative disk* seen as a diminishing signal intensity from nucleus pulposus, low signal Sharpey fibers disrupted by regions of higher signal intensity in the location of an anular tear, and slightly diminished disk height. A *severely degenerative disk* showed low signal intensity from the intervertebral disk and severely reduced disk height (Fig. 2). Findings of DDD on MR imaging such as disk herniation, lateral neural canal stenosis, central spinal canal stenosis, facet degeneration, thickened ligamentum flavum, and nerve root compression were recorded. Univariate logistic regression analysis was performed.

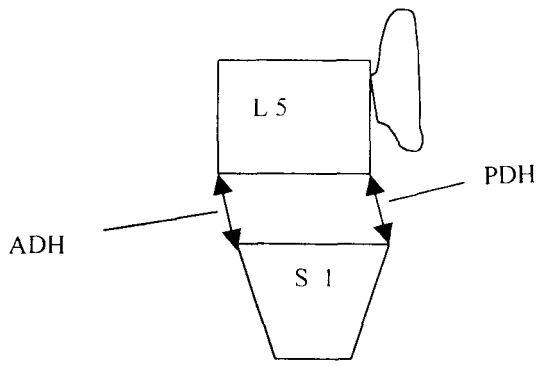


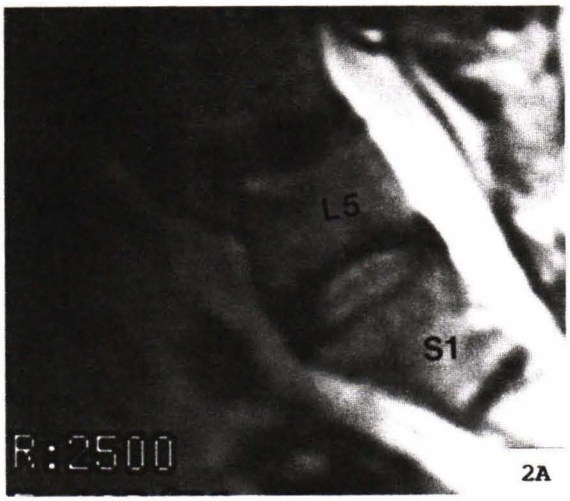
Fig. 1. The diagram demonstrates measurement of anterior disk height (ADH) and posterior disk height (PDH) in lateral LS spine film.

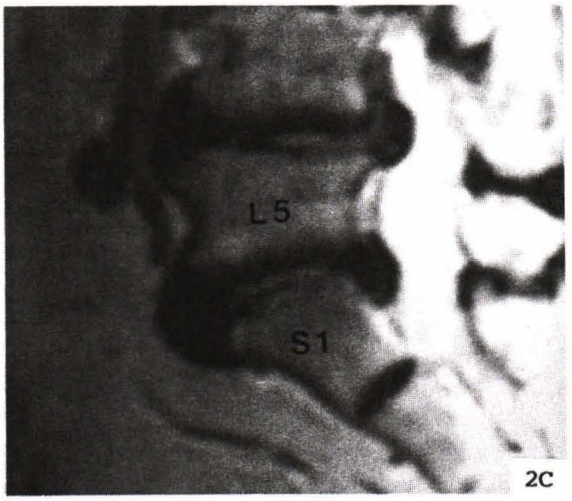
RESULTS

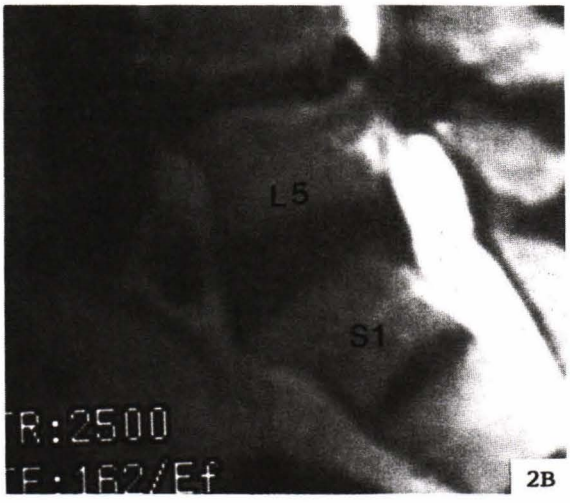
The patients were 75 females (mean age = 56.1 years) and 25 males (mean age = 55.0 years). Eleven patients had normal disk, 63 had mildly degenerative, and 26 had severely degenerative disks. In plain films, endplate sclerosis was found in 82 patients, marginal osteophyte in 54, and spondylolisthesis in 9 patients.

Anterior disk height with 95 per cent CI in patients with normal, mildly degenerative, and severely degenerative disks, respectively, were 11.3 (8.6-16.4), 12.3 (5.0-22.1), 8.8 (2.9-14.3) mm; and PDH were 5.5 (3.6-7.9), 5.7 (1.4-10.0), 4.1 (1.4-8.6) mm (Table 1) (Fig. 3).

When findings of DDD at LS junction were observed on plain films, we found varying degrees of disk degeneration (Table 2). When end plate sclerosis was observed on plain film; the disk was found to be normal, mildly degenerative, and







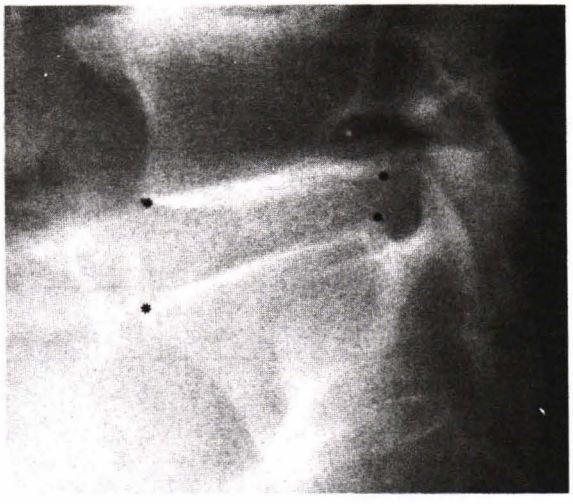


Fig. 2. Conventional T2-weighted sagittal MR images demonstrate three types of disk, A) normal disk, B) mildly degenerative disk, and C) severely degenerative disk. The markedly decreased height of disk posteriorly in B) and C) resulting PDH to be less than ADH.

Fig. 3. Lateral LS spine radiograph of mildly degenerative disk (ADH 11.2 mm, PDH 4.3 mm) matched to the MR image in Fig. 2B (the black dots indicate measured points).

Table 1. Anterior and posterior disk height (ADH and PDH)[a] in different degrees of DDD.

	Degree of DDD		
	Normal	Mild DDD	Severe DDD
ADH (mm)	11.3	12.3	8.8
	(8.6 – 16.4)	(5.0-22.1)	(2.9 – 14.3)
PDH (mm)	5.5	5.7	4.1
	(3.6-7.9)	(1.4-10.0)	(1.4-8.6)

[a] with 95% confidence interval (95% CI)

severely degenerative in 12 per cent, 57 per cent, and 31 per cent of cases, respectively. When marginal osteophyte and spondylolisthesis were seen; the analogous percentage was 7 per cent, 50 per cent, 43 per cent and 0 per cent, 37 per cent, 63 per cent, respectively.

When findings of DDD at LS junction were observed on plain films, many findings of degenerative change were also detected on MR imaging (Table 3).

Using univariate logistic regression analysis, separate plain film finding of DDD at LS junction had relative risk for certain abnormalities demonstrated by MR imaging (Table 4). In patients with endplate sclerosis demonstrated by plain film compared to those without it, the relative risk was 3.2 ($p < 0.05$) with associated lateral neural canal stenosis and was 4.2 ($p < 0.05$) with disk herniation. For spondylolisthesis; significant association was found between grading of spondylolisthesis and grading of DDD ($p < 0.05$), and between grading of spondylolisthesis and facet degeneration ($p< 0.05$). No radiographic finding showed significant relative risk for nerve root compression.

Table 2. Plain film findings of LS junction and degree of DDD by MR imaging (in percentage).

Plain film findings	MRI of disk		
	Normal	Mild DDD	Severe DDD
Endplate sclerosis (n=82)	12	57	31
Marginal osteophytes (n=54)	7	50	43
Spondylolisthesis (n=9)	0	37	63

Table 3. Plain film findings of LS junction with related MRI abnormalities (in percentage).

Plain film findings	MRI findings					
	Lat.stenosis[a]	Cent.stenosis[b]	Disk herniate	Facet degen.	Thick LF[c]	Root comp.[d]
Endplate sclerosis	62	27	35	41	28	27
Marginal osteophytes	63	30	35	43	28	31
Spondylolisthesis[e]	67	22	44	78	22	33

a Lateral neural canal stenosis
b Central spinal canal stenosis
c Thickening of ligamentum flavum
d Nerve root compression
e One case is grade 2, and 8 cases are grade 1

Table 4. Plain film findings of LS junction with relative risk[a] to have abnormalities in MR imaging.

Plain film findings[b]	MRI findings					
	Lat.stenosis[c]	Cent.stenosis[d]	Disk herniate	Facet abn.	Thick LF[e]	Root comp.[f]
Endplate sclerosis (n=82)	3.2[g]	1.9	4.2[g]	1.1	3.2	1.8
Marginal osteophytes (n=54)	1.8	1.7	1.7	1.3	1.4	1.4

a Relative risk in patients who have the above plain film findings compared to those without these findings
b Due to we recorded spondylolisthesis by grading, the number of each group is too small for statistical analysis
c Lateral neural canal stenosis
d Central spinal canal stenosis
e Thickening of ligamentum flavum
f Nerve root compression
g $p < 0.05$

DISCUSSION

During the normal aging process, the nucleus pulposus changes from a viscous hydrostatic structure to a desiccating fibrous mass[26,27], as well as decreasing the water content[28]. The signal alteration seen on T2-weighted images are consistent with the biochemical changes occurring within the disk, especially the hydration and dehydration of nucleus pulposus[8]. This degenerative process occurs at the time the plain film appears normal.

A lumbar disk is considered abnormal on plain film if its height is less than that of the disk above. LS junction is the area where diagnosis of DDD is difficult because of variation of the normal disk height. Cohn et al[11] reported that PDH was the most reliable criterion for detection of DDD at the LS junction. The authors stated that PDH $\leq$ 5.4 mm on plain lateral film indicated DDD, whereas, PDH $\geq$ 7.7 mm indicated absence of DDD. We found a wider range in our study: the PDH of < 5.5 mm to signify DDD and > 10.0 mm to exclude DDD. The mean values of ADH and PDH of mildly degenerative disks (12.3 and 5.7 mm, respectively) were conversely higher than that of a normal disk (11.3 and 5.5 mm, respectively). This may be due to the small number of normal disks in this present study or because of a wider range of normal disk space height in our population. We therefore used the mean values of "normal disk" as discriminating points, to signify that a value less than this will suggest DDD (11.3 mm for ADH & 5.5 mm for PDH). Caution should be made when applying these criteria because the magnification factor can be different due to machine setting. The PDH is less than ADH in some instances, may be explained by increased mechanical stress posteriorly or the presence of fewer annular fibers in this region[11,29] (Fig. 2 B, C).

Endplate sclerosis on plain film showed the highest percentage of associated normal disks on MR imaging (12%). Contradictory, endplate sclerosis showed a significant relative risk for disk herniation of 4.2 times and for lateral neural canal stenosis of 3.2 times compared to cases without it.

Marginal osteophyte did not show any significant relative risk. Torgerson et al[4] performed a comparative roentgenographic study of the asymptomatic and symptomatic lumbar spine and reported that marginal osteophyte can occur without disk degeneration, and conversely, disk degeneration can occur without marginal osteophyte. The authors used the criterion "narrowing of the lumbar disk" to indicate DDD and they studied multiple levels of lumbar spine. Our study, although using different criteria, showed a corresponding finding in that when marginal osteophyte was observed on plain film, the disks were normal in 7 per cent of cases. However, our study was limited to the LS junction.

When spondylolisthesis was observed on plain film, the disks were all degenerated. This is not an unexpected finding because spondylolisthesis, both anterior and posterior types (retrolisthesis), are classified as complications of degenerative change of spine[24]. No radiographic finding showed significant relative risk for nerve root compression.

In conclusion, ADH <11.3 mm or PDH < 5.5 mm indicates DDD at LS junction. Disks are degenerated when spondylolisthesis is detected. Endplate sclerosis observed on plain film has a significant relative risk for disk herniation and lateral neural canal stenosis.

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ภาวะเสื่อมของหมอนรองกระดูกสันหลังระดับลัมโบเซครัม : การวินิจฉัยโดยภาพรังสีและภาวะร่วมที่พบในภาพที่สร้างจากคลื่นแม่เหล็กไฟฟ้า

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การวินิจฉัยภาวะเสื่อมของหมอนรองกระดูกสันหลังระดับลัมโบเซครัม เป็นสิ่งที่ทำได้ยากโดยภาพรังสี เนื่องจากมีพิสัยของความปกติกว้างมาก และหลักเกณฑ์ที่ใช้ในการวินิจฉัยภาวะเสื่อมของหมอนรองกระดูกสันหลังระดับอื่นไม่สามารถใช้ได้กับระดับนี้ ได้ทำการศึกษาแบบย้อนหลังโดยการวิเคราะห์ภาพรังสีและภาพที่สร้างจากคลื่นแม่เหล็กไฟฟ้าของผู้ป่วย 100 รายที่มาด้วยอาการปวดหลังส่วนล่าง พบว่าค่าความสูงของหมอนรองกระดูกระดับลัมโบเซครัม ทางด้านหน้าที่น้อยกว่า 11.3 มม. หรือทางด้านหลังที่น้อยกว่า 5.5 มม. เป็นข้อบ่งชี้ภาวะเสื่อมของหมอนรองกระดูกระดับนี้ ค่าที่ได้นี่เป็นค่าที่ปรับปัจจัยการขยายภาพออกแล้ว เมื่อมีการเลื่อนของกระดูกสันหลังพบว่าหมอนรองกระดูกจะมีภาวะเสื่อมร่วมด้วยเสมอ การเห็น endplate sclerosis ในภาพรังสีมีความเสี่ยง (เปรียบเทียบกับการไม่เห็น endplate sclerosis) ที่จะพบการยื่นของหมอนรองกระดูกและการแคบของช่องทางออกด้านข้างของเส้นประสาทอย่างมีนัยสำคัญทางสถิติ ไม่พบความผิดปกติในภาพรังสีที่จะบอกถึงความเสี่ยงต่อการเกิดการกดทับเส้นประสาทอย่างมีนัยสำคัญทางสถิติ

คำสำคัญ : กระดูกสันหลัง, หมอนรองกระดูกเสื่อม, กระดูกสันหลัง, ภาพที่สร้างจากคลื่นแม่เหล็กไฟฟ้า

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