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Study Design: Retrospective analysis.
Objectives: To determine the relationship between pelvic tilt and lumbar disc degeneration.
Summary of Literature Review: The shape and the spatial orientation of the pelvis determine the organization of the lumbothoracic spine. The purpose of our study was to determine the relationship between pelvic tilt and lumbar disc degeneration.
Materials and Methods: Sixty patients over 50 years of age who had undergone lumbar spine magnetic resonance imaging were recruited. In individuals between 41 and 60 years of age, the normal pelvic tilt is 14°. Patients were divided into a low pelvic tilt (PT) group (<14°) and a high pelvic tilt (PT) group (≥14°). Lumbar disc degeneration was graded from I to V according to the Pfirrmann grade. We defined grades IV and V as high-grade degeneration and the others as low-grade degeneration. Radiologic parameters and lumbar disc degeneration were compared between these 2 groups.
Results: In the low PT group, the average degeneration grade of each lumbar segment was 2.61 in L1-L2, 2.61 in L2-L3, 3.00 in L3-L4, 3.39 in L4-L5, and 3.84 in L5-S1. The corresponding grades in the high PT group were 2.34 in L1-L2, 2.62 in L2-L3, 3.07 in L3-L4, 3.76 in L4-L5, and 3.55 in L5-S1. The grade of degeneration of the high PT group was significantly higher than that of the low PT group for L4-L5 (p=0.031). High-grade degeneration of the L4-L5 segment was significantly more common in the high PT group (odds ratio=4.65; 95% CI, 1.406-15.381; p=0.012).
Conclusions: Patients with high pelvic tilt had a higher grade of lumbar disc degeneration in the L4-L5 segment regardless of age or gender.

Key words: Lumbar disc degeneration, Pelvic tilt, MR

Introduction

There is an increasing recognition of the clinical importance of the sagittal plane alignment of the spine.[1] Changes in sagittal alignment may lead to kinematic changes in the lumbar spine. This may subsequently influence load bearing and the distribution of disc degeneration.[2]

Pelvic tilt is defined as the angle between the line connecting the midpoint of the sacral plate to the femoral heads axis and the vertical.[3] Pelvic tilt is positional parameter of pelvis reflecting compensatory changes of the pelvic orientation. When spinal kyphosis increases, the compensatory mechanism activates and the pelvic position changes.[4]

Conversely, the shape and the spatial orientation of the pelvis determines the organization of the lumbo-thoracic spine. In clinical practice the degree of pelvic tilt is commonly assessed because of its reported relationship to pelvic, spinal and lower limb pathologies.[5] Orientation of acetabulum depends on pelvis tilt.[6] Position of the acetabulum relates to the global sagittal balance of the spino-pelvic unit.[7] So pelvic tilt is a

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important parameter which determines relation between axial spine and lower limbs.

There are many literatures that analyzed relation between pelvic parameters and other radiologic parameters. But there are few literatures that analyzed the relationship between pelvic tilt and lumbar disc degeneration. The purpose of our study is to determine relation between pelvic tilt and lumbar disc degeneration.

Materials and Methods

We recruited patients over age above 50 years old who taken lumbar spine MRI from January 2013 to December 2014 who visited our orthopaedic clinic consecutively. Total 90 patients were recruited at the beginning of study. We reviewed their chart and their main symptom was back pain, buttock pain, leg pain and etc. We excluded patients who taken lumbar spine MRI due to motor vehicle accident or trauma because these traumatic event can cause change of natural lumbar lordosis. 30 patients were excluded then, 60 patients were evaluated.

Normal pelvic tilt between 40 and 60 years old is 14(±6)°.[8] Patients were divided into 2 groups according to the pelvic tilt. Radiologic parameters obtained from standing upright radiography and lumbar spine MRI were compared between low pelvic tilt (PT) group (<14) and high pelvic tilt (PT) group(≥14).

1. Inclusion criteria

The patients who visited our outpatient orthopaedic clinic with

1) Age above 50 years old

2) No history of surgery on spine

3) No recent History of trauma within 3 months

4) Patient with back pain with or without radiculopathy of lower extremities were included. Average age of all patient was 60.87(±6.55) years old. Average sagittal vertical axis was 10.59(±18.57). Average pelvic tilt was 14.67(±11.41) and average lumbar lordosis was 26.65(±7.22). Average sacral slope was 36.77(±9.35) and average pelvic incidence was 49.65(±12.57). Of 60 patients, 30 were male and 30 were female (Table 1).

2. Measures analyzed

Spino-pelvic parameters were measured on full spine radiographs in a standing position. The radiographs were measured using standard techniques recommended by the Scoliosis Research Society. Standard lateral radiographs obtained for sagittal balance are on a 3-foot long cassette. The patient stands upright with his or her arms positioned on a support in front of them, their head facing forward. The X-ray tube is positioned 72 inches from the patient.

Sagittal vertical axis was measured as the offset between the posterior corner of the sacrum and the vertical line passing through the vertebral body of C7. The pelvic incidence, defined as the angle between the line perpendicular to the sacral plate at its midpoint and the line connecting this point to the axis of the femoral heads was measured in standing lateral radiograph. The sacral slope was measured as the angle between the superior plate of S1 and a horizontal line. Pelvic tilting was measured as the angle between the line connecting the midpoint of the sacral plate to the femoral heads axis and the vertical line. Lumbar lordosis was measured between upper end plate of L1 and superior end plate of sacrum in the same standing lateral radiograph.

Lumbar disc degeneration was measured based on Magnetic Resonance Imaging-based grading System. Grading of disc degeneration of the 60 patients was performed by 3 spinal surgeons (observers) in a blinded fashion using the T2-weighted sagittal images. Five lumbar levels (L1-2, L2-3, L3-4, L4-5, L5-S1) were chosen and 300 discs were assessed on T2-weighted mid sagittal images.

This classification takes into account the nucleus signal intensity, the nucleus structure, the distinction between the nucleus pulposus and the annulus fibrosus, and the disc height from Grade I to V.[9] We defined grade IV and V as high grade degeneration because height of intervertebral disc is moderated decreased or collaped in which grades disc space narrowing is obvious in plain radiograph.

3. Statistical analysis

Grade of disc degeneration were compared between low PT group and high PT group using t-test. And risk of high grade degeneration was analyzed using chi-square test and binary logistic regression test controlling age and gender. All statistical analyses were performed using the SPSS version 17.0.0 statistics

package (SPSS, Inc., Chicago, IL). A value of $p<0.05$ was accepted as significant.

Results

Average age of low PT group was 59.77(±6.96) and that of high PT group was 62.03(±5.98). The difference of age between low PT group and high PT group was not statistically significant (p=0.229).

Average pelvic tilt of low PT group was 5.55(±5.12)° and that of high PT group was 24.41(±7.46)°. The difference of pelvic tilt between both group was statistically significant ($p<0.001$). Average lumbar lordosis of low PT group was 45.94(±12.27)° and that of high PT group was 39.17(±10.25)°. The lumbar lordosis of both group was statistically significant (p=0.025).

Average sacral slope of low PT group was 39.58(±9.68)° and that of high PT group was 33.76(±8.09)°. The sacral slope was statistically higher in low PT group (p=0.015). Average pelvic incidence of low PT group was 43.13(±10.52)° and that of high PT group was 56.62(±10.82)°. The pelvic incidence was statistically higher in high PT group (p=0.025). Average sagittal vertical axis of low PT group was 11.76(±18.76) mm and that of high PT group was 9.42(±17.62) mm. The sagittal vertical axis between both group was not statistically different (p=0.256). Among both group, weight, height and body mass index were not significantly different (Table 2).

Among low PT group, average degeneration grade of each lumbar segment was 2.61 in L1–2, 2.61 in L2–3, 3.00 in L3–4, 3.39 in L4–5 and 3.84 in L5–S1. And that of high PT group was 2.34 in L1–2, 2.62 in L2–3, 3.07 in L3–4, 3.76 in L4–5 and 3.55 in L5–S1. Grade of degeneration of high PT group was significantly higher compared with low PT group in L4–5(p=0.031) (Table 3) (Fig. 1, 2). Percentage of high grade degeneration of L4–5 segment was 48.4% in low PT group and 79.3% in high PT group (p=0.013) (Table 4). Ratio of high grade degeneration of L4–5 was significantly higher in high PT group(OR 4.65, 95%CI 1.406–15.381, p=0.012) (Table 5).

Table 1. Descriptive data of patients

Age (yr)	60.87(±6.55)
Weight (kg)	61.60(±9.71)
Height (cm)	160.80(±6.88)
Body mass index (kg/m^2)	23.73(±2.77)
Lumbar lordosis	26.65(±7.22)
Pelvic tilt	14.67(±11.41)
Sacral slope	36.77(±9.35)
Pelvic incidence	49.65(±12.57)
Sagittal vertical axis (mm)	10.59(±18.57)
Male/Female	30/30

Values are presented as mean ± standard deviation.

Table 2. Comparison between Low PT group and High PT group

	Low PT group (31)	High PT group (29)	p-value
Age(yr)	59.77(±6.96)	62.03(±5.98)	0.184
Weight(kg)	61.71(±10.35)	61.48(±9.16)	0.929
Height(cm)	161.19(±6.62)	160.38(±7.24)	0.651
Body mass index (kg/m2)	23.64(±2.93)	23.83(±2.93)	0.792
Lumbar lordosis	45.94(±12.27)	39.17(±10.25)	0.025
Pelvic tilt	5.55(±5.12)	24.41(±7.46)	<0.001
Sacral slope	39.58(±9.68)	33.76(±8.09)	0.015
Pelvic incidence	43.13(±10.52)	56.62(±10.82)	<0.001
Sagittal vertical axis(mm)	11.76(±18.76)	9.42(±17.62)	0.256
Male:Female	15:16	15:14	0.796

Discussion

There are many studies that analyze age-related spinal alignment changes.[1,3,8,10-13] Gelb et al reported that increasing age correlated to a more forward sagittal vertical axis with loss of distal lumbar lordosis but without an increase in thoracic or thoracolumbar kyphosis.[14] In our study lumbar disc degeneration was more severe in distal lumbar segments especially at L4-5 and L5-S1. Degeneration of L4-5 segments was more severe in patient with high pelvic tilt more than 14 degrees. These high pelvic tilt may be compensatory mechanism of pelvis to maintain sagittal balance against loss of lumbar lordosis.

In healthy adults, a low pelvic incidence decreased sacral-slope and the lordosis is flattened. And a high pelvic incidence increased sacral-slope and the lordosis is more pronounced.[15] In our study, pelvic incidence of high PT group was significantly higher than low PT group. But sacral slope and lumbar lordosis of high PT group was lower than low PT group. In symptomatic patients with high pelvic incidence, high pelvic tilt can be indicator of lumbar disc degeneration, decreased lumbar lordosis and decreased sacral slope.

The majority of asymptomatic individuals are able to

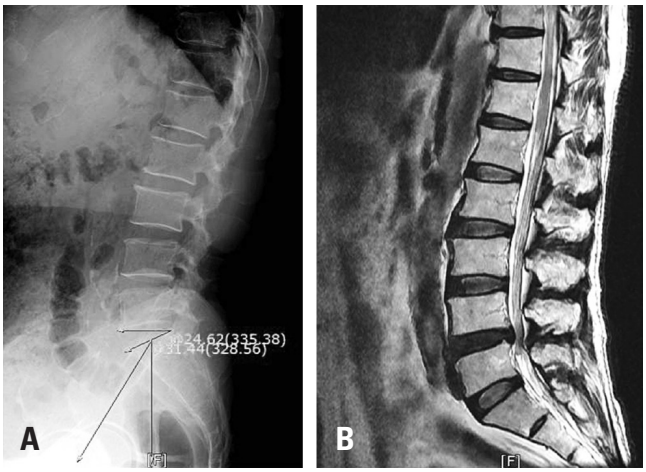

Fig. 1. Radiography of a 67-year-old male with high pelvic tilt. **(A)** Upright lateral X-ray. **(B)** T2 sagittal image of lumbar magnetic resonance imaging.

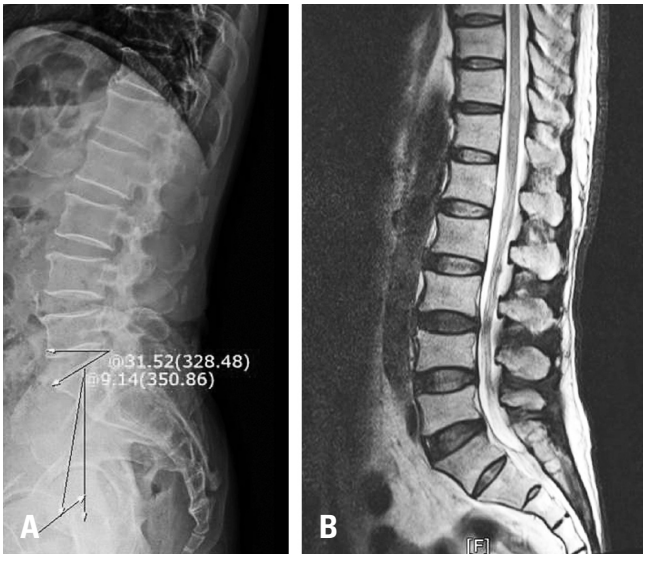

Fig. 2. Radiography of a 69-year-old male with low pelvic tilt. **(A)** Upright lateral X-ray. **(B)** T2 sagittal image of lumbar magnetic resonance imaging.

Table 3. Comparison of radiologic parameter on MRI between low PT group and high PT group using t-test

	Low PT group (31)	High PT group (29)	p-value
L1-2	2.61(±0.92)	2.34(±0.55)	0.174
L2-3	2.61(±0.72)	2.62(±0.73)	0.967
L3-4	3.00(±0.63)	3.07(±0.59)	0.665
L4-5	3.39(±0.67)	3.76(±0.64)	0.031
L5-S1	3.84(±0.82)	3.55(±0.99)	0.224

Table 4. Comparison of radiologic parameter between low PT group and high PT group using chi-square test

	Low PT group(31)	High PT group(29)	p-value
L1-2 (high grade)	24(77.4%):7(22.6%)	28(96.6%):1(3.4%)	0.053
L2-3 (high grade)	27(87.1):4(12.9%)	25(86.2%):4(13.8%)	1.000
L3-4 (high grade)	25(80.6%):6(19.4%)	23(79.3%):6(20.7%)	0.897
L4-5 (high grade)	16(51.6%):15(48.4%)	6(20.7%):23(79.3%)	0.013
L5-S1 (high grade)	9(29.0%):22(71.0%)	9(31.0%):20(69.0%)	0.866

Table 5. Odd ratio of high grade degeneration of L4-5 on MRI by logistic regression analysis

	Odd ratio	p-value	95% CI
High pelvic tilt	4.650	0.012	1.406~15.381
Gender	1.845	0.307	0.569~5.979
Age	0.973	0.554	0.890~1.065

maintain their sagittal alignment despite advancing age. Loss of distal lumbar lordosis is most responsible for sagittal imbalance in those individuals who do not maintain sagittal alignment. In our study, lumbar lordosis of high PT group was significantly lower compared with low PT group. Decreased lumbar lordosis from lumbar disc degeneration in high PT group may impair sagittal balance and induce pelvic retroversion. So increased pelvic tilt more can be used as radiologic marker indicating lumbar disc degeneration especially at L4-5 segment. Further evaluation with lumbar MRI will be helpful for evaluating pathology on distal lumbar segments. The pelvis may compensate for decreasing lumbar lordosis by retroverting and increasing pelvic tilt and decreasing the sacral slope.[16]

Schwab et al reported normal pelvic parameters in sagittal plane.[8] Between 41 and 60 years old, normal pelvic tilt was 14(±6)°. Inclusion criteria of our study was age above 50 years old and we divided patients into low pelvic tilt (PT) group (<14) and high pelvic tilt (PT) group (≥14). With advancing age, they reported change of pelvic parameter as an increase of the thoracic kyphosis ,an anterior shift of C7 plumb line and pelvis retroversion. In our study, average pelvic tilt was 14.67(± 11.41)°. From our study, we can conclude these change of pelvic parameter start from L4-5 segment.

Sagittal spinal alignment in lumbar disc herniation exhibits more anterior translation of the C7 plumb line, less lumbar lordosis, and a more vertical sacrum.[17] And similar changes occurs in high PT group with higher grade of lumbar disc degenerations except anterior translation of plumb line. Lumbar disc herniation is usually acute change , but lumbar disc degeneration is gradual change and compensation mechanism of sagittal balance may occur.

The Dubousset cone of economy concept illustrates the importance of spinopelvic balance in maintaining an upright posture and minimizing energy expenditure with standing and walking.[10] In our study, sagittal vertical axis between both group was not significantly different. But lumbar disc degeneration was severe in patient with high pelvic tilt. Loss of lumbar lordosis in patient with high pelvic tilt may lead to kinematic changes in the lumbar spine. This may subsequently influence load bearing and contribute lumbar disc degeneration.

The significance of our study is that the degenerative change of lumbar segment mainly occurred at L4-5 level and this change decreased lumbar lordosis. Pelvic retroversion occurred to compensate anterior shift of plumb line. So assessments of L4-5 segment in patients with high pelvic tilt are recommended.

The limitation of our study is that sequence of pelvic retroversion and lumbar disc degeneration is unknown because study was performed retrospectively. And subjects of this study consist of symptomatic patients associated with lumbar disc degeneration, then these can results in exaggerated grade of lumbar disc degeneration in our study. So prospective study with healthy adults without symptoms to analyze between pelvic tilt and lumbar disc degeneration will be needed. We did not check severity of pain, so we cannot analyze relation between pelvic tilt and severity of symptoms. Our study was performed to analyze relationship between radiologic parameters, so we cannot tell clinical relevance of our results. Further study to analyze relationship between radiologic and clinical parameters will be needed.

Conclusions

Patients with high pelvic tilt had higher grade of lumbar disc degeneration on L4-5 segment regardless of age and gender. Lumbar disc degeneration mainly occurs at L4-5 segment and this results in decrease of lumbar lordosis and high pelvic tilt.

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Original Article

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골반 경사각과 요추간판 퇴행의 관계

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연구 계획: 후향적 연구

목적: 골반 경사각과 요추간판 퇴행성 변화의 관계를 분석하고자 하였다.

선행문헌의 요약: 골반의 형태와 경사도는 흉요추부의 만곡에 영향을 준다. 골반 경사각과 요추간판의 퇴행성 변화와의 관계를 분석하고자 하였다.

대상 및 방법: 본원 정형외과에 내원한 50세 이상의 환자들 중 요추부 MRI를 촬영한 60명의 환자를 대상으로 하였다. 40~60세 환자의 골반 경사각의 평균은 14도 정도로 알려져 있다. 본 연구에서는 연구 대상을 저골반 경사군(<14)과 고골반 경사군(≥14)으로 분류하였다. 요추간판의 퇴행성 변화는 Pfirrmann 분류에 따라 다섯 등급으로 분류하였다. Pfirrmann 분류에서 IV, V등급을 고등급 퇴행으로 그 미만을 저등급 퇴행으로 분류하였다. 두 군간의 방사선학적 지표와 MRI상의 추간판 퇴행성 변화를 비교하였다.

결과: 저골반 경사군에서 요추간판의 평균 퇴행 등급은 제 1-2요추간에서 2.61, 제 2-3요추간에서 2.61, 제 3-4요추간에서 3.00, 제 4-5요추간에서 3.84, 제 5요추-제 1천추간에서 3.84로 나타났다. 고골반 경사군에서 요추간판의 평균 퇴행 등급은 제 1-2요추간에서 2.34, 제 2-3요추간에서 2.62, 제 3-4요추간에서 3.07, 제 4-5요추간에서 3.76, 제 5요추-제 1천추간에서 3.55로 나타났다. 제 4-5요추간판에서 퇴행성 변화가 고골반 경사군에서 저골반 경사군에 비해 유의하게 높았다(p=0.031). 제 4-5요추간판에서 4등급 이상의 심한 퇴행 등급의 비율 역시 고골반 경사군에서 유의하게 높았다(OR 4.65, 95%CI 1.406-15.381, p=0.012).

결론: 골반 경사각이 14도 이상으로 큰 환자에서 제 4-5요추간판에서 4등급 이상의 심한 퇴행 변화가 많았다.

색인 단어: 요추간판, 골반 경사삭, 자기공명영상

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