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The progression of osteoarthritis of the hip increases degenerative lumbar spondylolisthesis and causes the change of spinopelvic alignment

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1. Introduction

Low back pain is one of the most common musculoskeletal conditions with an incidence of 73% in the general population.[1] Patients with hip osteoarthritis (HOA) secondary to acetabular dysplasia have been reported to show a high incidence of low back pain and sciatica.[2] A high proportion of HOA patients complain with lumbago. Parvizi et al. reported an incidence of complication with lumbago of 49.4%.[3] The incidence of complication increases with progression of the hip joint deformity and joint contracture. One of the causes of HOA is thought to be compensatory change of the lumbar spine alignment due to leg length discrepancy and joint contracture of the hip.

Offierski and MacNab discussed the relationship between HOA and lumbar spine disease and described the hip spine syndrome in 1983.[4] They suggested that the relevance of hip deformity and spinal alignment is very important to understand the pathology of HOA. They categorized this syndrome into four groups. They considered postural changes in the low back in the form of hyperlordosis, sacral inclination, and secondary foraminal stenosis at L4–L5 as possible causes of aggravated HOA symptoms.

More recently, many researchers investigated the sagittal alignment of spinopelvic alignment in conjunction with HOA. The lumbar spinal alignment change associated with leg length discrepancy, limitation of the range of motion of the hip, and the degenerative changes in the paravertebral muscle has been reported to be associated with the progression of HOA.[5] Compensatory hyperlordosis of the lumbar spine and anterior inclination of the pelvis is induced in patients with developmental acetabular dysplasia to improve the coverage of the acetabulum to the femoral head.[6,7] Okuda et al. reported that the pelvic inclination tends to decrease in terminal stage osteoarthritis patients compared with early stage osteoarthritis patients.[8] With the progression of OA, changes in the inclination of the pelvis may aggravate the joint stability. A relationship between low back pain and change in spinal alignment has been reported.[9] Therefore, low back pain related to the spinopelvic alignment change may cause the shortage of anterior acetabular hip coverage and progression of HOA. A higher incidence of degenerative spondylolisthesis was reported in patients with HOA. The compensatory hyperlordosis of the lumbar spine that is related to developmental acetabular dysplasia might cause degenerative spondylolisthesis.[10] Few studies have investigated the relationship between lumbar spinal spondylolisthesis and the progression of HOA.

The objectives of the present study were to investigate the incidence of lumbar spondylolisthesis and spinopelvic alignment changes in patients with HOA stratified by stage, and to clarify the relationship between lumbar spondylolisthesis, spinopelvic alignment, and the progression of HOA.

2. Materials and methods

This retrospective study was approved by our institutional review board. Patients with developmental dysplasia of the hip were included in the study. Developmental dysplasia was defined as a center edge

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Table 1
Demographic data of the patients in the 4 groups.

	Total	Preosteoarthritis	Early stage	Advanced stage	Terminal stage	*P* Value
		200	35	42	37	86
Gender						
male/female	25/175	4/31	3/39	6/31	8/88	
Age (yrs)	54.2 ± 13.8	44.3 ± 13.9	52.0 ± 14.5	58.0 ± 10.5	62.0 ± 9.2	< 0.001
BMI (Kg/m2)	23.6 ± 4.9	22.8 ± 4.3	23.2 ± 4.5	24.1 ± 5.8	24.0 ± 5.9	N.S
ROM						
Flexion	97.6 ± 16.2	106.0 ± 5.5	106.1 ± 8.7	100.0 ± 9.3	83.9 ± 18.5	< 0.001
Abduction	31.7 ± 13.4	45.0 ± 10.6	37.4 ± 10.8	31.8 ± 12.4	20.6 ± 10.7	< 0.001

angle < 25°. Patients with leg length discrepancy greater than 3 cm; severe subluxation and dislocation of the hip classified as Crowe group III or IV; severe contracture of the hip joint (flexion < 60°); or history of osteotomy were excluded from the study. In total, 200 consecutive patients with HOA secondary to developmental dysplasia of the hip, treated in our institution between February 2011 and December 2013, were investigated in this study.

Among the 200 patients included in the present study, 25 were male and 175 were female (Table 1). The average age of all the patients was 54.2 years. The clinical stage of the disease was preosteoarthritis (n = 35; mean age, 44.3 years; acetabular dysplasia with no osteoarthritic change), early stage (n = 42; mean age, 52.0 years; slight joint space narrowing and abnormal subchondral sclerosis), advanced stage (n = 37; mean age, 58.0 years; marked joint space narrowing), and terminal stage (n = 86; mean age, 62.0 years; obliteration of the joint space) osteoarthritis.[11] There were significant differences in the age among these groups, but no significant differences in sex and body mass index (Table 1).

2.1. Parameters of spinopelvic alignment

All patients underwent standing lateral radiograph evaluations of the lumbar spine and hip joint with the arm in the fist-on-clavicles position, elbows fully flexed with fists resting on the clavicles, and knees and hips fully extended. The spinopelvic parameters including sacral slope angle (SS),[12] disc angle (DA),[13] lumbar lordotic angle (LL),[14] and pelvic tilt angle (PT)[5] were measured as reported previously (Fig. 1).

The presence of lumbar spondylolisthesis was diagnosed when a lumbar vertebra showed ≥3 mm of anterior translation compared to the adjacent lower vertebra. From these results, the incidence of degenerative lumbar spondylolisthesis in each clinical stage of HOA and the spinopelvic alignment change related to the complication of spondylolisthesis were investigated.

2.2. Statistical analysis

Statistical analysis was performed using Stat View 5.0 (SAS Institute Inc. Cary, NC, USA). The mean values of all the subgroups were compared using the Mann-Whitney *U* test, the X2 test, or analysis of variance. A p value < 0.05 was considered statistically significant.

3. Results

3.1. Sagittal spinopelvic alignment parameters in each stage of HOA

In each stage of HOA (preosteoarthritis, early stage, advanced stage, and terminal stage), the average disc angle was 13.9°, 13.1°, 9.4°, 9.3°, and the average sacral slope angle was 36.4°, 37.3°, 38.2°, 33.6°,respectively (Table 2). These angles significantly decreased with the progression of HOA (Figs. 2 and 3). However, no significant differences were noted for the lumbar lordotic angle and pelvic tilt angle in each clinical stage of HOA.

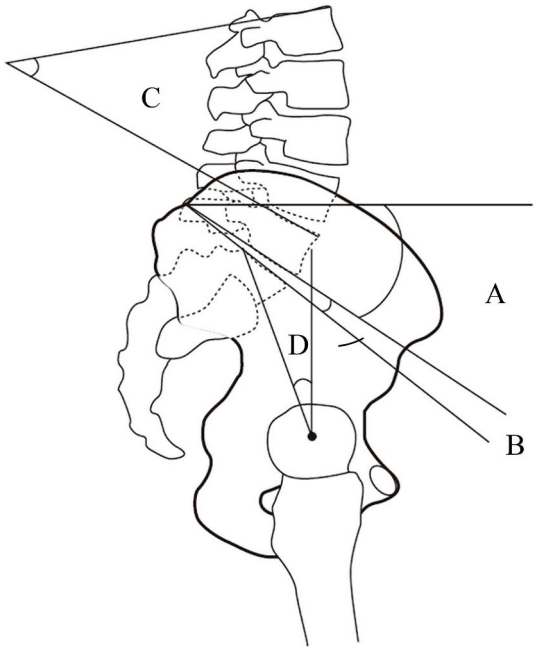

Fig. 1. Parameters of sagittal spinopelvic alignment. A: sacral slope angle (the angle between horizontal line and upper border of sacrum, B: disc angle of L5/S1 (the angle between lower end of L5 and upper end of sacrum), C: lumbar lordotic angle (Cobb angle between L1 and L5), D: pelvic tilt angle (the angle between the line extending from the posterior side of the upper edge of the sacrum to the middle point of the line connecting the central point of the femoral head and perpendicular line).

3.2. The incidence of degenerative lumbar spondylolisthesis and the clinical stage of HOA

The incidence of the degenerative lumbar spondylolisthesis was 28.5% among all the HOA patients. Degenerative lumbar spondylolisthesis was mainly observed in L4 (64.1%), L3 (23.1%), and L5 (10.3%). The incidence of degenerative lumbar spondylolisthesis was 8.6% in the preosteoarthritis, 21.4% in the early stage, 40.5% in the advanced stage, and 42.0% in the terminal stage. The incidence was significantly higher in the advanced stage compared with that in the early stage, and was associated with the progression of HOA (Fig. 4).

The pelvic tilt and the disc angle in the patients with spondylolisthesis were significantly larger than those in patients without spondylolisthesis (pelvic tilt angle: 23.4° vs. 19.6°, p < 0.01; disc angle: 11.6° vs. 9.3°, p < 0.05). The sacral slope angle was not significantly different between the two groups (Table 3).

Table 2
Radiographic analysis of various spinopelvic alignment parameters in each clinical stage of HOA.

	Preosteoarthritis	Early stage	Advanced stage	Terminal stage	*P* Value
Disc angle (L5/S) (DA)	13.9 ± 4.7	13.1 ± 5.7	9.4 ± 6.2 *†	9.3 ± 5.9 ‖§	
Sacral slope angle (SS)	36.4 ± 6.5	37.3 ± 10.1	38.2 ± 7.5	33.6 ± 10.9‡¶	
Lumbar lordotic angle (LLA)	28.7 ± 8.5	26.9 ± 12.0	29.9 ± 9.9	31.2 ± 14.0	N.S
Pelvic tilt angle (PT)	18.2 ± 8.8	20.8 ± 10.2	19.7 ± 6.4	19.8 ± 7.3	N.S.

*p < 0.01; ‖p < 0.01, compared with the preosteoarithritis group.
†p < 0.01; §p < 0.01; ‡p < 0.05, compared with the early group.
p < 0.01, compared with the advanced group.

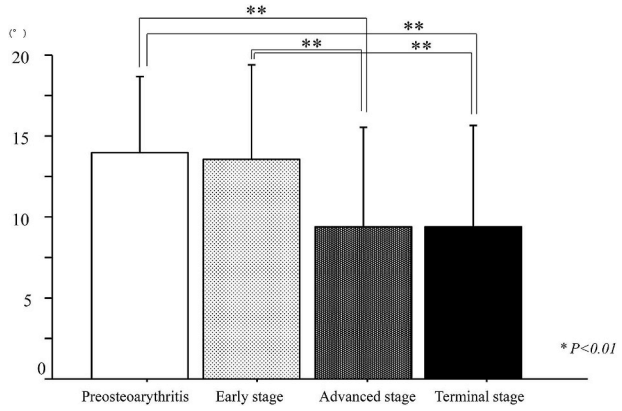

Fig. 2. Disc Angle (L5/S) (DA)in each clinical stage of HOA.

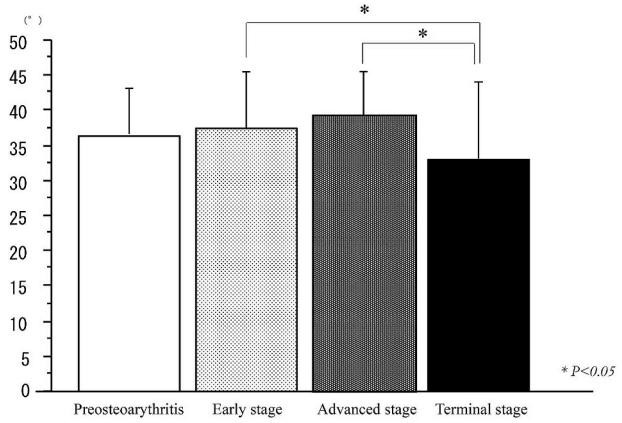

Fig. 3. Sacral slope angle (SS) in each clinical stage of HOA.

4. Discussion

The incidence of lumbar spondylolisthesis has been found to be approximately 5% in a cadaver study.[15] This incidence has been reported to be 3.8–5.6% among the general Japanese population.[16] Among Japanese patients with HOA, the incidence of lumbar spondylolisthesis has been found to range between 31.0% and 36.0%.[17] In the present study, 28.5% of lumbar spondylolisthesis was found. The difference of the incidence of spondylolisthesis between the studies may reflect differences in the stage of HOA between the patients. Based on the findings in previous and present study, there seems to be an association between the presence of HOA and an increased incidence of lumbar spondylolisthesis.

Few studies have investigated the incidence of degenerative lumbar spondylolisthesis in patients with HOA. In the present study, we investigated the incidence of degenerative lumbar spondylolisthesis in the different stages of HOA. Our findings showed that in the early stage of HOA, the incidence of degenerative lumbar spondylolisthesis was twice as high as in the advanced stage of HOA compared with that in the early stage. Our findings suggest a significant relationship between lumbar spondylolisthesis and the progression of HOA. The natural cause of spondylolisthesis is considered to be a trigger for the progression of HOA.

Various studies have evaluated the factors that cause HOA to become complained with lumbar spondylolisthesis. Takemitsu et al. reported that lumbar spine alignment changes cause the complication.[18] Genetic factors, hormonal factors, muscle relaxants, and pregnancy history have been reported to be involved in the occurrence of degenerative lumbar spondylolisthesis.[11,19]

The relationship between HOA and lumbar spinal alignment was reported in previous reports.[4] In the initial stage of HOA associated with acetabular dysplasia, hyperlordosis of the lumbar spine and anterior shift of the center of gravity are thought to occur with pelvic anterior tilt and hip joint flexion contracture.[2] As a result, in the early to advanced stage of HOA, the load to the lumbar facet joint increases,

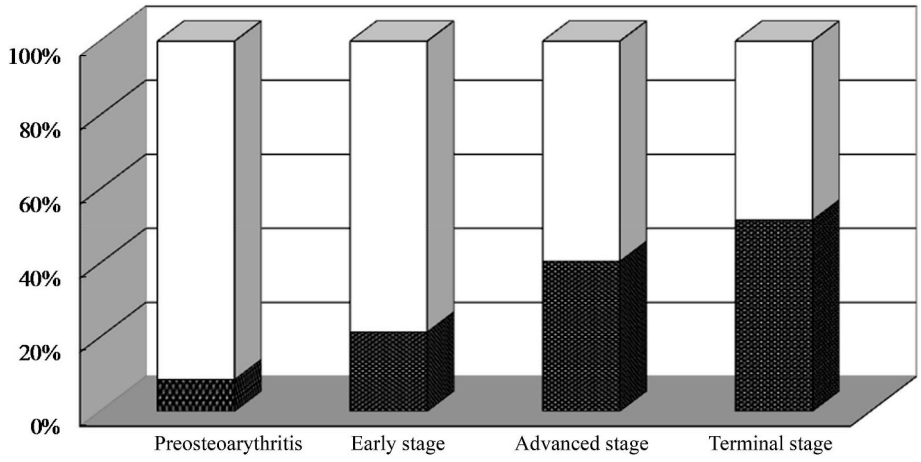

Fig. 4. The incidence of the degenerative lumbar spondylolisthesis in patients with HOA.

Table 3
Spinopelvic alignment change associated with spondylolisthesis.

	Spondylolisthesis (+)	Spondylolisthesis (−)	*P* Value
Case (%)	57 (28.5%)	143 (71.5%)	
Age	63.5 ± 8.2	51.1 ± 13.7	*< 0.0001***
Leg length discrepancy (mm)	10.8 ± 12.8	8.9 ± 9.9	*0.0220**
Sharp angle (°)	46.1 ± 4.4	46.6 ± 4.1	*0.4425*
CE angle (°)	10.9 ± 12.2	11.0 ± 12.4	*0.8755*
Spinopelvic sagittal alignment			
Lumbar lordotic angle (°)	31.9 ± 12.5	30.0 ± 11.9	*0.6627*
Disc angle L5/S1 (°)	11.6 ± 5.9	9.3 ± 5.8	*0.0401**
Sacral slope angle (°)	36.3 ± 10.4	35.6 ± 9.1	*0.1828*
Pelvic tilt angle (°)	19.6 ± 6.5	23.4 ± 8.3	*0.0171**

HOA is considered to become gradually complained with lumbar spondylolisthesis.[3] With the progression of HOA, the lumbar kyphosis occurs under the influence of age changes, and the pelvic retroversion and hip joint extended position occur next to compensate for the anterior movement of the center of gravity.[18] The coverage of the acetabular roof decreases, and the hip joint load increases in relation to the increasing offset between the hip joint center and gravity axis.

A significant posterior change in the pelvic tilt was shown in patients with HOA complicated by lumbar spondylolisthesis. Funao et al. reported a sacral slope angle of 34.0° and pelvic tilt angel of 23.5° in the general population.[20] In the patients with terminal stage of HOA in the present study, the sacral slope angle was 38.2°, and the pelvic tilt angle was 19.7°. The pelvic tilt in these patients was more posterior than that of the general population. Okuda et al. investigated the pelvic inclination changes between early stage HOA patients and terminal stage HOA patients.[11] Their results are consistent with our results. In consideration of the pathology of HOA progression, the complication of lumbar spondylolisthesis may be a risk factor related to the progression of HOA. In the future, there is a need for further research about the spinopelvic alignment changes according to HOA progression.

The stage of HOA might have been aggravated by the sagittal spinal imbalance as a result of the posterior pelvic tilting. In HOA with a balanced sagittal spinopelvic alignment, the load of the hip joint due to the effect of aggravating factors such as degenerative lumbar spondylolisthesis or vertebral compression fracture, and progression of the stage of HOA are expected to increase. Therefore, the prevention of the onset of HOA, the progression of HOA, and the progression of degenerative lumbar disease may be an important key.

The present study has several limitations. First, this study was not a case-control study and there was no proper matching of subjects among the groups, before the data analysis. We did not investigate whether changes in HOA parameters or aging affected the change in spinopelvic alignment and the incidence of lumbar spondylolisthesis. Second, the accuracy of the measurements of the pelvic spine alignment changes was limited. However, the method of radiographic evaluation is well established,[11] and the small measurement error is supported. Further study is warranted in a larger sample size with more accurate measurements.

In conclusion, the incidence of the degenerative lumbar spondylolisthesis increased with progression of the stage of HOA. The complication of degenerative lumbar spondylolisthesis remarkably increased from the early stage to advanced stage. Patients with HOA complicated by the lumbar spondylolisthesis were is significantly older compared to non-complicated cases, and a leg length difference was noted. In addition, it was estimated that pelvic retroversion progressed. Spinopelvic alignment changes were considered to have a significant impact on the progression of HOA. In the treatment of HOA, it is important to prevent the complication of spondylolisthesis and consider the changes in sagittal spinopelvic alignment.

Conflicts of interest

The authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent

Informed consent was obtained from all individual participants included in the study.

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