Prevalence of Radiographic Osteoarthritis and Structural Abnormalities of the Hip in Patients with Contralateral Hip Fractures

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Background: *The prevalence of osteoarthritis (OA) of the hip varies considerably among different races and ethnicities. Some bony abnormalities associated with the development of hip OA.*
Objective: *To determine the prevalence of radiographic OA and structural abnormalities of the hip in patients with contralateral hip fractures.*
Material and Method: *Pelvic AP radiographs of patients more than 60 years of age who had contralateral hip fractures were reviewed. Radiographic diagnosis of hip OA was determined by minimum joint space width ≤2 mm. Kellgren-Lawrence classification was also used for evaluation. Structural abnormalities of the acetabulum and proximal femur regarding femoroacetabular impingement were also assessed.*
Results: *Plain radiographs of 152 patients with an average age of 77.4 years were included. One hundred and thirteen patients (74.3%) were female. Prevalence of radiographic OA of the hip (minimum joint space width ≤2 mm) was 9.9%. In addition, 9.2% of hips were Kellgren-Lawrence grade 2 or higher. Pistol grip deformity was found in 6 patients and all were male. Five patients (3.3%) had cross-over sign. No protrusio acetabuli was detected. Coxa profunda was identified in 72 patients (47.4%). Average center-edgeangle was 37.1±6.2 degrees in hips with Coxa profunda, and 35.9±5.3 degrees in hips without Coxa profunda (p = 0.180).*
Conclusion: *Prevalence of radiographic OA of the hip in patients with contralateral hip fractures was 9.9%. Coxa profunda was a common radiographic finding.*

Keywords: *Osteoarthritis, Hip, Prevalence, Coxa profunda*

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Osteoarthritis (OA) of the hip is a common musculoskeletal disorder in the elderly that can adversely affect patient activities and quality of life. Plain radiograph is a basic diagnostic tool in clinical practice that is frequently used to determine the presence and prevalence of hip OA. Previous studies reported that prevalence of hip OA varies considerably among different races and ethnicities[1-4]. However, the prevalence of hip OA in Southeast Asian populations has not been well elucidated. Methods of diagnosis could also affect hip OA prevalence rates. A systematic review found that the mean prevalence of radiographic OA of the hip according to Kellgren-Lawrence (KL) classification and minimum joint space width (JSW) decreased when using stricter criteria[1].

There are multiple risk factors for progression of hip OA. Several etiologies have been well-described, including osteonecrosis of the femoral head, post-traumatic conditions, infection, inflammatory arthritis, and abnormal bony morphology. Numerous reports have documented the association between structural abnormalities in femeroacetabular impingement (FAI) and the development of radiographic OA of the hip[5-8]. Nevertheless, debate continues regarding which abnormalities should be considered as major risk factors for hip OA[8-10].

In order to reduce patient radiation exposure, some epidemiological studies in hip OA were conducted by reviewing pre-existing colon radiograph and intravenous urography[2,11].

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The present study is a preliminary study that was designed to determine the prevalence of radiographic OA and structural abnormalities of the hip using plain radiograph of patients with contralateral hip fractures.

Material and Method

After our study protocol was approved by the Siriraj Institutional Review Board (SIRB: Faculty of Medicine Siriraj Hospital, Mahidol University), we retrospectively reviewed pelvic anteroposterior (AP) radiographs of patients aged more than 60 years who sustained contralateral hip fractures. Adequacy of radiograph was determined by pelvic orientation and pelvic tilt. Pelvic orientation was assessed using the critical limits of Tonnis' foramen obturator index within 0.7-1.8[12]. Pelvic tilt was evaluated by the distance between the superior borders of the symphysis to the sacrococcygeal joint within 3.2 cm in men and 4.7 cm in women[13].

Minimum JSW was the decisive parameter used to establish the presence of hip OA in this study. Minimum JSW was the lowest of the superolateral, apical, and superomedial JSW measurements[14]. Radiographic OA of the hip was diagnosed as minimum JSW ≤2 mm. Hips were also evaluated by KL classification[15].

Each proximal femur was measured for femoral neck-shaft angle, medial proximal femoral angle (MPFA)[16], and triangular index[17]. The presence of a pistol grip deformity was established when the triangular index was ≥0 mm[8]. Acetabular morphology was evaluated by center-edge (CE) angle of Wiberg[18], Coxa profunda[18], protrusio acetabuli[18], and cross-over sign[19] (Table 1). A subset of 50 pelvic AP radiographs was repeat assessed by 2 investigators to evaluate the reliability of measurements.

Normality of continuous data was evaluated by Kolmogorov-Smirnov test. Student's t-test was used to analyze normally distributed continuous data and Mann-Whitney U test was used to evaluate non-normally distributed continuous data. Fisher's exact test was employed to evaluate categorical data. Inter-observer reliability was assessed using intraclass correlation coefficient and standard error of measurement for continuous variables and kappa coefficient for categorical variables. SPSS for Windows version 18.0 (SPSS, Inc., Chicago, Illinois, USA) was used for all statistical analyses. A *p*-value less than 0.05 was considered statistically significant.

Table 1. Definitions of variables inpelvic AP radiograph

Radiographic variables	Definitions
Tonnis' foramen obturator index[12]	Maximum horizontal width of the right obturator foramen devided by left obturator foramen width
Joint space width[14]	Distance between the acetabular roof (condensed subchondral bone) and the part of the femoral head facing it
Femoral-neck shaft angle[16]	Angle between the anatomical axis of the femur and the axis of the femoral neck
Medial proximal femoral angle[16]	Angle between the anatomical axis of the femur and a line connecting the center of the femoral head and the tip of the greater trochanter
Triangular index[17]	The index determines the relationship between the distance from the femoral head center to a point at the superior border of the femoral head-neck junction located by a perpendicular line at the lateral half radius point of the longitudinal axis of the femoral neck (R) and the inherent radius of the femoral head (r); also described by the formula: R-(r+2 mm)
Pistol grip deformity[8]	The proximal femur with the triangular index ≥0 mm
Center-edge index of Wiberg[18]	The angle between a line through the center of the femoral head, perpendicular to the transverse axis of the pelvis and a line through the center of the femoral head, passing through the most superolateral point of the sclerotic weight-bearing zone of the acetabulum
Coxa profunda[18]	The floor of the fossa acetabuli touches or is medial to the ilioischial line
Protrusio acetabuli[18]	The medial aspect of the femoral head is medial to the ilioischial line
Cross-over sign[19]	The line of the edge of anterior acetabular wall progress does cross the line of the edge of the posterior acetabular wall before reaching the lateral edge of the sourcil

Results

Two hundred and twenty-three pelvic AP radiographs were reviewed, with 71 hips being excluded due to inadequate pelvic position. Accordingly, 152 pelvic AP radiographs of patients with contralateral hip fractures were included. The average age of subjects in this study was 77.4 years. Patient demographic information, clinical characteristics, and results of radiographic evaluation are shown in Table 2.

Prevalence of radiographic OA of the hip as determined by minimum JSW ≤2 mm was 9.9%. However, prevalence rates changed to 2.6% and 26.3% when using cut-off points of 1.5 mm and 2.5 mm, respectively. When hips were evaluated by KL classification, 9.2% of patients were classified as KL grade 2 to 4. However, only 1.3% of hips were classified as KL grade 3 or 4 (Table 2). Prevalence of hip OA according to minimum JSW and KL classification tended to increase with increases in patient age (Table 3).

Pistol grip deformity of the proximal femur was identified in 6 male patients (15.4%) and in no female patients. For acetabular variables, average CE angle in male and female patients was 36.2 degrees and 36.6 degrees, respectively. Coxa profunda was a common finding that was identified in 38.5% of male and 50.4% of female patients.There was no significant difference

Table 2. Characteristics and radiographic findings of patients by gender

	Female	Male	Total
Characteristics			
Patients (n, %)	113 (74.3)	39 (25.7)	152 (100)
Age (years, mean ± SD)	77.5±7.3	76.7±7.0	77.4±7.2
Femoral neck fracture (n, %)	65 (57.5)	21 (53.8)	86 (56.6)
Intertrochanteric fracture (n, %)	48 (42.5)	18 (46.2)	66 (43.4)
Studied side: left hip (n, %)	66 (58.4)	18 (46.2)	84 (55.3)
Joint space width (JSW)			
Superolateral JSW (mm: mean ± SD)	4.3±1.1	4.7±0.9	4.4±1.0
Apical JSW (mm: mean ± SD)	3.8±1.0	4.6±1.1	4.0±1.1
Superomedial JSW (mm: mean ± SD)	3.1±0.8	3.5±1.0	3.2±0.9
Minimal JSW (mm: mean ± SD)	3.1±0.8	3.0±0.8	3.0±0.8
Minimal JSW ≤1.5 mm (n, %)	3 (2.7)	1 (2.6)	4 (2.6)
Minimal JSW ≤2.0 mm (n, %)	11 (9.7)	4 (10.3)	15 (9.9)
Minimal JSW ≤2.5 mm (n, %)	34 (30.1)	6 (15.4)	40 (26.3)
Kellgren and Lawrence classification			
KL 1 (n, %)	102 (90.3)	36 (92.3)	138 (90.8)
KL 2 (n, %)	9 (8.0)	3 (7.7)	12 (7.9)
KL 3 (n, %)	2 (1.7)	0 (0.0)	2 (1.3)
KL 4 (n, %)	0 (0.0)	0 (0.0)	0 (0.0)
KL 2 to 4 (n, %)	11 (9.7)	3 (7.7%)	14 (9.2)
Proximal femoral variables			
Neck shaft angle (degrees: mean ± SD)	135.2±5.5	133.8±4.6	134.8±5.3
MPFA (degrees: mean ± SD)	83.5±5.4	83.7±5.8	83.5±5.5
Triangular index (mm: median, range)	-2.0 (6.4-0.3)	-2.0 (5.1-1.3)	-2.0 (-6.4-1.3)
Triangular index ≥0 mm (n, %)	0 (0.0)	6 (15.4)	6 (3.9)
Acetabular variables			
CE angle (degrees: mean ± SD)	36.6±5.9	36.2±5.3	36.5±5.7
Hip with CE angle <20° (n, %)	0 (0.0)	0 (0.0)	0 (0.0)
Hip with CE angle 20° to 24.9° (n, %)	2 (1.8)	0 (0.0)	2 (1.3)
Hip with CE angle 25° to 39° (n, %)	76 (67.3)	30 (76.9)	106 (69.7)
Hip with CE angle >39° (n, %)	35 (31.0)	9 (23.1)	100 (28.9)
Coxa profunda (n, %)	57 (50.4)	15 (38.5)	72 (47.4)
Protusio acetabuli (n, %)	0 (0.0)	0 (0.0)	0 (0.0)
Cross-over sign (n, %)	1 (0.9)	41 (0.3)	5 (3.3)

JSW = joint space width; KL = Kellgren and Lawrence; MPFA = medial proximal femoral angle; CE angle = center-edge angle

between the CE angle of the hips with coxa profunda and those without coxa profunda (37.1±6.2 degrees vs. 35.9±5.3 degrees; p = 0.180). When comparing between hips with minimum JSW ≤2 mm and those with minimum JSW >2 mm, there was no significant difference for age, gender, or the radiographic variables evaluated in this study (Table 4).

Inter-observer reliability is shown in Table 5. A majority of the measurements used in the present study had very good reliability[20]. Evaluation of the triangular index demonstrated good reliability, while KL classification and presence of coxa profunda had moderate reliability[20].

Discussion

Prevalence of radiographic OA of the hip in this study population, as determined by minimum JSW ≤2 mm, was 9.9%. Coxa profunda was a common radiographic finding, being identified in 47.4% of patients and more commonly found in females. Pistol grip deformity was the bony abnormality that more commonly observed in male patients.

Prevalence of radiographic OA of the hip varies considerably among different populations. A current systematic review of 23 studies reported that prevalence of hip OA ranged from 0.9% to 27.0%, with a mean of 8.0%[1]. Several studies reported higher prevalence of radiographic OA of the hip in European and North American populations than in the Asian population[2-4]. Results of previous studies in hip OA prevalence in Asian populations[1-4,21]. The present study found prevalence rates that were comparable to most of those studies when using minimum JSW ≤1.5 mm (2.6%) or KL grade 3 or 4 (1.3%). Dagenais et al[1] demonstrated that prevalence of radiographic OA varies considerably according to the methods and criteria used

Table 3. Results of radiographic hip osteoarthritis by age group

Variables	Age group (years)			
	60-69 (n = 22)	70-79 (n = 78)	80-89 (n = 46)	≥90 (n = 6)
Minimum JSW ≤2 mm (n, %)	2 (9.1)	8 (10.3)	4 (8.7)	1 (16.7)
Kellgren and Lawrence classification				
KL 2 (n, %)	2 (9.1)	6 (7.7)	4 (8.7)	1 (16.7)
KL 3 (n, %)	0 (0.0)	1 (1.3)	0 (0.0)	0 (0.0)
KL 4 (n, %)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
KL 2 to 4 (n, %)	2 (9.1)	7 (9.0)	4 (8.7)	1 (16.7)

JSW = joint space width; KL = Kellgren and Lawrence

Table 4. Patient characteristics and radiographic findings of the hip according to the minimum joint space width

Variables	JSW ≤2 mm (n = 15)	JSW >2 mm (n = 137)	p-value
Age (years: mean ± SD)	79.3±7.0	77.0±7.2	0.310
Female (n, %)	13 (86.7)	100 (73.0)	0.356
Femoral neck-shaft angle (degrees: mean ± SD)	133.7±7.3	135.0±5.0	0.935
MPFA (degrees: mean ± SD)	82.4±5.3	83.7±5.5	0.395
Triangular index (mm: mean ± SD)	-2.9±1.1	-2.3±1.2	0.127
Triangular index ≥0 mm (n, %)	0 (0)	6 (4.4)	0.999
CE angle (degrees)	38.1±5.3	36.3±5.7	0.260
Hips with CE angle <25 degrees (n, %)	0 (0)	2 (1.5)	
Hips with CE angle 25 to 39 degrees (n, %)	11 (73.3)	95 (69.3)	0.896
Hips with CE angle >39 degrees (n, %)	4 (40.0)	40 (29.2)	
Coxa profunda (n, %)	10 (66.7)	62 (45.3)	0.172
Cross-over sign (n, %)	0 (0)	5 (3.6)	0.999

JSW = joint space width; MPFA = medial proximal femoral angle; CE angle = center-edge angle

Table 5. Results of inter-observer reliability tests of radiographic findings

Radiographic parameters	Coefficient value	95% confidence interval	Standard error of measurement
Superolateral JSW	0.83	0.70 to 0.91	0.4 mm
Apical JSW	0.91	0.84 to 0.95	0.3 mm
Superomedial JSW	0.84	0.72 to 0.91	0.4 mm
Minimum JSW	0.90	0.82 to 0.94	0.3 mm
KL grade	0.56	0.22 to 0.89	-
Neck shaft angle	0.92	0.86 to 0.95	2.0 degrees
MPFA	0.90	0.82 to 0.94	1.8 degrees
Triangular index	0.62	0.34 to 0.79	0.7 mm
CE angle	0.91	0.85 to 0.94	1.7 degrees
Coxa profunda	0.60	0.37 to 0.82	-

JSW = joint space width; KL = Kellgren and Lawrence; MPFA = medial proximal femoral angle; CE angle = center-edge angle

for diagnosis, with a resulting decrease in prevalence when using stricter criteria.

Several studies have investigated association between abnormal hip morphology (especially FAI) and the development of OA. Ecker et al[7] demonstrated that high alpha angle, high lateral CE angle, pistol grip deformity, and cross-over sign were associated with presence of arthritis. Bardakos et al[16] reported that progression from mild to moderate OA of the hip with pistol grip deformity was partially influenced by lower medial proximal femoral angle and localized positive posterior wall sign. Clohisy et al[18] reported that increased alpha angle and acetabular inclination were the strongest predictors of subsequent total hip arthroplasty in FAI patients. Gosvig et al[8] reported that deep acetabular socket and pistol grip deformity were common radiographic findings thatare associated with increased risk of hip OA. However, the definitions of deep acetabular socket, coxa profunda, and protrusio acetabuli in their study were based on CE angle $\geq$45 degrees, which was different from our study and other studies.

Limited data has been reported regarding prevalence of FAI in the Asian population. Takeyama et al[22] reported 0.6% prevalence of FAI in 843 Japanese patients who underwent hip surgery at their institute. In the present study, 6 male patients had pistol grip deformity and 5 hips had cross-over sign, but none of them had developed hip OA. Furthermore, the present study found that coxa profunda was more common in females and that it has no association with the amount of CE angle. These data corresponded to several recent studies. Nepple et al[10] reported that coxa profunda was identified in 76% of asymptomatic hips, in 64% of hips with FAI, and that it was more common in females. Only 22% of hips with coxa profunda had acetabular overcoverage (CE angle >40 degrees or acetabular inclination <0°). A study by Anderson et al[9] also found no difference in lateral CE angle between hips with and without coxa profunda.

The present study has some mentionable limitations. First, patients in this study were elderly, predominantly female and had hip fractures that may not reflect prevalence of general population. Moreover, the correlation between incidence of hip fractures and radiographic OA of the hip has not been well-established[23,24]. Second, only a plain AP radiograph was used to evaluate hip OA in this study. Some radiographic parameters for evaluation of cam type FAI including alpha angle and head-neck offset, which require a lateral view of the proximal femur could not be measured and this may have underestimated the prevalence of femoroacetabular impingement. Finally, this retrospective study did not assess the pre-existing symptoms of patients with contralateral hip fractures. As such, radiographic prevalence in this study does not reflect or represent the prevalence of symptomatic OA in this population.

Conclusion

Prevalence of radiographic OA of the hip in patients with contralateral hip fractures was 9.9%. Coxa profunda was a common radiographic finding.

What is already known on this topic?

Prevalence of radiographic OA and structural abnormalities of the hip varies according to race, ethnicity, and method of diagnosis. A current systematic

review of 23 studies reported that prevalence of hip OA ranged from 0.9% to 27.0%, with a mean of 8.0%.

What this study adds?

This study reports a prevalence rate of radiographic OA of the hip in patients with contralateral hip fractures (minimum JSW ≤2 mm) of 9.9%. Coxa profunda was a common radiographic finding, but it did not associate with the amount of center edge (CE) angle of Wiberg.

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Potential conflicts of interest

None.

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ความชุกของข้อสะโพกเสื่อมและลักษณะโครงสร้างผิดปกติในภาพถ่ายรังสีของผู้ป่วยที่มีกระดูกบริเวณข้อสะโพกด้านตรงข้ามหัก

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ภูมิหลัง: *ความชุกของโรคข้อสะโพกเสื่อมมีความหลากหลายตามเชื้อชาติและอาจมีความสัมพันธ์กับลักษณะการผิดรูปของกระดูก*

วัตถุประสงค์: *เพื่อหาความชุกของข้อสะโพกเสื่อมและลักษณะโครงสร้างผิดปกติในภาพรังสีของผู้ป่วยที่มีกระดูกบริเวณข้อสะโพกด้านตรงข้ามหัก*

วัสดุและวิธีการ: *การศึกษานี้ได้ประเมินภาพถ่ายรังสีกระดูกเชิงกรานของผู้ป่วยที่มีอายุมากกว่า 60 ปี ซึ่งมีกระดูกต้นขาส่วนต้นของสะโพกด้านตรงข้ามหักในตำแหน่งคอกระดูกและ intertrochanteric วินิจฉัยข้อสะโพกเสื่อมจากภาพถ่ายรังสีโดยใช้ระยะที่แคบที่สุดของช่องข้อต่อน้อยกว่าหรือเท่ากับ 2 มิลลิเมตร และมีการประเมินด้วยการจำแนกของ Kellgren-Lawrence มีการเก็บข้อมูลลักษณะโครงสร้างที่ผิดปกติของส่วนเบ้าสะโพกและกระดูกต้นขาส่วนต้น โดยเฉพาะอย่างยิ่งลักษณะของภาวะ femoroacetabular impingement*

ผลการศึกษา: *การศึกษาภาพถ่ายรังสีส่วนเชิงกรานของผู้ป่วย 152 ราย ซึ่งมีอายุเฉลี่ย 77.4 ปี และร้อยละ 74.3 เป็นเพศหญิง พบความชุกของข้อสะโพกเสื่อมร้อยละ 9.9 ตามเกณฑ์การมีระยะที่แคบที่สุดของช่องข้อต่อน้อยกว่าหรือเท่ากับ 2 มิลลิเมตร ผู้ป่วยร้อยละ 9.2 มีลักษณะการจำแนกของ Kellgren-Lawrence ระดับ 2 ถึง 4 พบผู้ป่วย 6 รายมีการผิดรูปแบบ pistol grip ซึ่งทั้งหมดเป็นเพศชาย มีผู้ป่วย 5 ราย (ร้อยละ 3.3) มี Cross-over sign ในการศึกษานี้ไม่พบลักษณะเบ้าสะโพกแบบ Protrusio acetabuli แต่พบลักษณะแบบ Coxa profunda ในผู้ป่วย 72 ราย (ร้อยละ 47.4) โดยพบว่าค่ามุม center-edge เฉลี่ยเป็น 37.1±6.2 องศาในเบ้าสะโพกซึ่งมีลักษณะ Coxa profunda และมีค่าเฉลี่ยเป็น 35.9±5.3 องศาในเบ้าสะโพกซึ่งไม่มีลักษณะ Coxa profunda ($p = 0.180$)*

สรุป: *ความชุกของข้อสะโพกเสื่อมจากภาพถ่ายรังสีของผู้ป่วยที่มีกระดูกบริเวณสะโพกด้านตรงข้ามหักคือ ร้อยละ 9.9 และลักษณะตามโครงสร้างผิดปกติที่พบบ่อยคือ Coxa profunda*