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Ptosis of the hip: a new radiographic finding in patients undergoing femoroacetabular osteoplasty

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ABSTRACT

Ptosis is a newly described phenomenon appearing on AP radiographs of patients undergoing femoroacetabular osteoplasty (FAO), and refers to a reverse break down in Shenton's Line. Thorough characterization of this phenomenon is needed to better understand the hip morphology and pathologic ramifications. Our goal was to define the radiographic hip parameters accompanying a break down in Shenton's Line and to determine how these values compare with standard values in normal hips. Using two independent readers, we retrospectively reviewed the medical records and preoperative supine radiographs of 630 patients (1260 hips) who underwent FAO by a single surgeon between 2003 and 2016. Prevalence of hip pathology and 28 radiographic parameters in ptosis hips was measured, as well as a comparison between unilateral ptosis hips and contralateral normal hips. Of the 53 patients (106 hips) who fulfilled the criteria for the study, 94 hips had a Shenton's Line break down of at least 5 mm. Sixty-nine percent of ptosis hips had femoroacetabular impingement (FAI), 70.2% had coxa profunda, and 52.1% had partial joint space narrowing. Ptosis hips had 1.05 mm less lateral subluxation ($P = 0.012$), 2.28° larger Center-edge angle ($P = 0.046$), 2.59° smaller Sharp angle ($P = 0.011$) and 2.49% smaller extrusion index ($P = 0.016$) compared with contralateral normal hips. FAI is prevalent in patients with a positive ptosis sign. The high prevalence of partial joint space narrowing could suggest eventual osteoarthritis. We believe our results demonstrate the importance of further investigation of a positive ptosis sign on AP pelvic radiographs.

INTRODUCTION

Anatomical abnormalities associated with femoroacetabular impingement (FAI) are known risk factors for the development of hip osteoarthritis (OA) [1, 2]. To improve disease classification and identification, radiographic classifications of the hip and femoral head are actively refined.

Ptosis is a newly described phenomenon appearing on AP radiographs of patients undergoing femoroacetabular osteoplasty (FAO), and refers to a reverse break down in Shenton's Line (Figs 1a–c and 2). Although a break up in Shenton's Line is seen in many dysplastic patients [3–5] and is recognized for its osteoarthritic ramifications [3], a break down in Shenton's Line has not been characterized in the literature. A thorough characterization of this phenomenon may further help clinicians better understand the present hip morphology and potential pathologic ramifications.

We aimed to define the radiographic characteristics accompanying a break down in Shenton's Line by measuring common radiographic hip parameters of patients with this ptosis phenomenon and determining how these values compare with standard values in normal hips. Also, we aimed to find the prevalence of common pathologic conditions in patients with a positive ptosis sign.

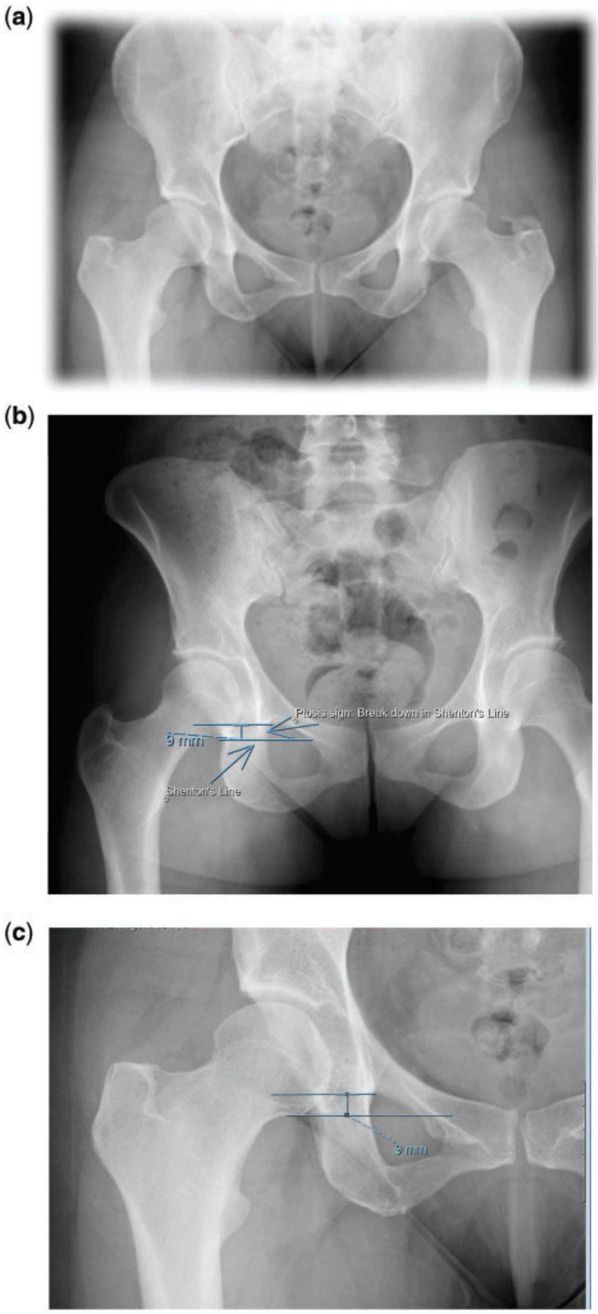

Fig. 1. (**a**) Positive ptosis sign in bilateral hips. (**b**) Positive ptosis sign: a break down in Shenton's Line greater than 5 mm. (**c**) Determination of the break down in Shenton's Line: positive ptosis sign.

METHODS

Participants

We retrospectively reviewed the medical records and preoperative radiographs of 630 patients (1260 hips) from patients who underwent FAO by a single orthopedic surgeon (JP) between 2003 and 2016. Inclusion criteria consisted of a Shenton's Line break down of at least 5 mm [6, 7], proper pelvic tilt, and proper pelvic rotation. A break of Shenton's Line of at least 5 mm was considered a significant interruption based on previous analysis of Shenton's Line, since femoral rotation and improper pelvic tilt can alter this measurement [8]. Patients with a history of any prior surgery on the designated hip were excluded from the study. For those patients who had previous FAO on the designated hip, superior head–neck offset, extrusion index of the femoral head, and sphericity index of femoral head measurements were excluded, since these parameters were altered by this procedure, but other parameters of those patients were included in the analysis. Fifty-three patients (106 hips) remained for final analysis. The following patient demographic data; gender, age, body mass index (BMI), history of FAI, history of DDH were recorded using institutional database (eClinicalWorks).

Supine anterior-posterior (AP) radiographs were obtained with feet positioned in 15° internal rotation. The X-ray tube to film distance was 120 cm. Radiographs required proper pelvic tilt and pelvic rotation. Proper pelvic tilt is defined as a distance of 1–3 cm [8–10] between the inferior tip of the coccyx and the superior edge of the pubic symphysis. Proper pelvic rotation is defined as the symmetrical appearance of bilateral obturator foramen as well as negligible horizontal offset between the projected vertical continuation of the inferior tip of the coccyx and the center of the superior edge of the pubic symphysis [9, 10].

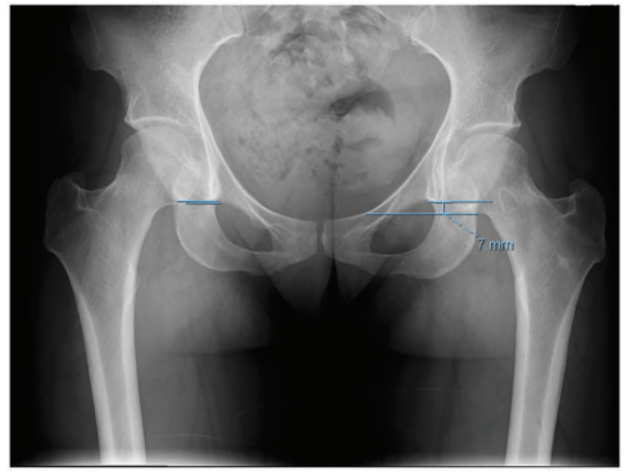

Fig. 2. Patient presenting with positive ptosis sign on left hip and negative ptosis sign on right hip (normal Shenton's Line).

Radiographic measurements

Radiographic measurements were performed using Sectra PACS software [11]. The radiographic measurements made are summarized in Table I with the addition of

Table I. Definitions of the investigated radiographic hip parameters

Parameter	*Definition*	*Accepted normal values*
Shenton's line break (mm)	Imaginary line connecting the medial aspect of the femoral neck to the superior pubic ramus [26]. The vertical distance of disruption of this Shenton's Line is measured by determining the distance between the most superior aspect of the continuation of the curvature of the femoral neck and the most superior aspect of the continuation of the curvature of the obturator foramen in making Shenton's Line.	<5
True acetabular depth (mm)	Determined by making a line from the lateral sourcil to the upper corner of the ipsilateral pubic symphysis. The distance from this line to the deepest part of the acetabulum is then measured [20].	>9 [21]
Acetabular depth to width (D/W)	Draw a line connecting the superolateral edge and the inferomedial edge of the acetabulum. The distance of this line is then calculated, which is the distance of the acetabular opening (A–B distance). A perpendicular line is then drawn from the first line to the deepest part of the acetabulum. By calculating the percentage of the depth to the width, D/W is determined.	>38% [22]
Later subluxation (L) (mm)	The distance from the teardrop to the medial aspect of the femoral head.	<10 [7]
Peak to edge distance (D) (mm)	The distance from the most vertical aspect of the acetabulum to the lateral edge of the acetabulum.	>12 [22]
M–Z distance (mm)	The distance between the M point and the center of the femoral head. Measure of the concentricity of femoral head and the acetabulum.	3.9 ± 1.7 [23]
ACM angle	The angle from the lateral aspect of the acetabulum, the deepest point of the acetabulum and the midpoint (M point) of the acetabular opening.	45 ± 3 [24]
Lateral center edge angle	The angle between the lateral aspect of the sourcil of the acetabulum and the line crossing through the center of the femoral head that is perpendicular to the horizontal. Measures the coverage of the acetabulum.	23–33 [25]
Sharp angle	The angle formed by the lateral aspect of the sourcil, the inferior tip of the ipsilateral teardrop and the horizontal. Measures the inclination of the acetabulum.	38–42 [25]
Tonnis angle	The angle formed between the line connecting the lateral and medial aspects of the sourcil and the horizontal. Measures the inclination of the weight bearing surface of the acetabulum.	0–10 [9]
Femoral head radius (mm)		Female: 27 [26] Male: 31 [27]
Superior head neck offset (mm)	The distance between the superior aspect of the femoral neck and corresponding femoral head. Indicator of cam impingement.	>8 [18]
Inferior head neck offset (mm)	The distance between the inferior aspect of the femoral neck and corresponding femoral head. Indicator of cam impingement.	>8 [18]
Femur neck length (mm)		35.9 ± 4.3 [27]

(continued)

Table I. (continued)

Parameter	*Definition*	*Accepted normal values*
Neck shaft angle	The angle between the femoral neck and femoral shaft.	120–135, 129.23 ± 6.24 [28]
Sphericity index of femoral head	Draw a line perpendicular to the horizontal that runs along the medial aspect of the femoral head. Draw a second perpendicular line that runs along the superior most point of the femoral head. Draw a third perpendicular line running along the lateral most aspect of the femoral head. The distance from the first line to the second line is A. The distance from the first line to the third line is B. Then calculate A/B.	50% [29]
Extrusion index of femoral head	Draw a line perpendicular to the horizontal that runs along the medial aspect of the femoral head. Draw a second perpendicular line that runs along the lateral aspect of the acetabulum. Draw a third perpendicular line running along the lateral most aspect of the femoral head. The distance from the second line to the third line is A. The distance from the first line to the third line is B. Then calculate A/B. Measure of acetabular coverage.	17–27% [25]
Crossover sign	Follow the posterior wall of the acetabulum. Positive if the posterior wall intersects with the anterior wall of the acetabulum. Sign of retroversion.	
Posterior wall sign	Positive if the center of the femoral head is lateral to the posterior wall of the acetabulum. Sign of retroversion.	
Coxa profunda	Positive if the acetabular fossa is observed to touch or is medial to the ilioischial line.	
Protrusio acetabuli	Positive if the femoral head is observed to touch or is medial to the ilioischial line.	

distance between tear drops, femoral head centers, ischial tuberosities, and height of pelvis, and joint congruity. Joint congruity is a subjective categorization system to evaluate the alignment of the curvature of the femoral head within the acetabulum [12]. Excellent joint congruity describes a femoral head with almost identical curvature to the acetabulum. Good joint congruity describes curvature of the acetabulum and femoral head that is not identical, but joint space is adequately maintained. Fair joint congruity describes partial narrowing of the joint space, which is any location between the acetabulum and the femoral head where the distance is 3 mm or less. Poor joint congruity describes partial loss of the joint space. Some femoral heads had to be reoriented on the radiograph using the reposition tool on the PACS software so the femoral shaft was perpendicular to the horizontal, while maintaining constant orientation of the femoral head within the acetabulum. Radiographic measurements of general hip morphology of ptosis hips were also made according gender to reflect the variability of patient hip size.

Statistics

Two independent double-blinded readers performed radiographic measurements to account for inter-observer bias. Correlation between reader estimates was determined using a paired t-test. Correlation (r) of 1.0 indicated perfect agreement, >0.80 indicated almost perfect agreement, 0.61–0.80 indicated substantial agreement, 0.41–0.60 indicated moderate agreement and 0.21–0.40 indicated fair agreement. A linear mixed effects regression was also performed to account for patient variability. This test compared the radiographic parameters of the 12 patients who had a unilateral positive ptosis sign and no ptosis sign on the contralateral hip. For the binary prevalence outcomes, McNemar's Chi-squared test with continuity correction and Cohen's Kappa test for 2 raters were performed.

Table II. Prevalence of known hip pathologies in all hips with positive ptosis sign, patients with unilateral ptosis sign and contralateral hips with no ptosis sign

	Positive ptosis sign hips total (n = 94)	*Positive ptosis sign unilateral hips (n = 12)*	*No ptosis sign contralateral hips (n = 12)*	*McNemar's Chi-squared test with continuity correction*	*Cohen's Kappa for 2 raters*
Condition	*Number (%)*	*Number (%)*	*Number (%)*	P-*value*	P-*value*
FAI	65/94 (69.1)	5/12 (41.7)	11/12 (91.7)	0.221	0.292
DDH	48/94 (51.1)	7/12 (58.3)	9/12 (75)	1	0.007
Retroversion	40/94 (42.5)	4/12 (33.3)	4/12 (33.3)	1	0.030
Coxa vara	9/94 (9.6)	1/12 (8.33)	1/12 (8.33)	NA	0.001
Coxa valga	7/94 (7.4)	1/12 (8.33)	1/12 (8.33)	1	0.753
Coxa profunda	66/94 (70.2)	11/12 (91.7)	10/12 (83.3)	1	0.020
Fair joint congruity (partial joint space narrowing)	49/94 (52.1)	4/12 (33.3)	3/12 (25.0)	1	0.005

These two tests compared the 12 patients who had a unilateral positive ptosis sign and no ptosis sign on the contralateral hip. McNemar's looked for significant difference between the two cohorts and Cohen's Kappa looked for significant similarity between the two cohorts. These statistics were performed using the software R: R Foundation for Statistical Computing in Vienna, Austria [13]. *P*-values for Tables IV and V were calculated using a two-sample *t*-test.

RESULTS

Of these 53 patients (106 hips), 94 hips had a Shenton's Line break down of at least 5 mm, which is considered a positive ptosis sign. Forty-one of the 53 patients had bilateral ptosis signs (77.4%; 82 hips) and 12 patients had a unilateral ptosis sign (12 hips). None of the patients presenting with a unilateral ptosis sign had a Shenton's Line break up on the contralateral hip. Of the 53 patients, 39 were female (73.6%) and 14 were male (26.4%). The average age was 36.36 ± 10.68 years (range 15–59 years) with an average BMI of 24.95 ± 3.88.

Many of the hips presenting with a positive ptosis sign also presented with other pathologic conditions of the hip, summarized in Table II. Sixty-five of the 94 hips (69.1%) with a positive ptosis sign had FAI. Forty-eight of the 94 hips (51.1%) with a positive ptosis sign had DDH. Thirty-two of the 94 hips (34%) with a positive ptosis sign presented with both FAI and DDH. Sixty-six ptosis hips (70.2%) presented with coxa profunda, and no hips presented with protrusio acetabuli. The number of ptosis hips presenting with fair joint congruity was 49/94 (52.1%), good joint congruity was 44/94 (46.8%), and excellent joint congruity was 1/94 (1.1%). According to McNemar's Chi-squared test with continuity correction and Cohen's Kappa test for 2 raters regarding the prevalence of pathologic conditions, there were no significant observable differences between the hips of those patients who had a unilateral positive ptosis sign and contralateral normal hips (Table II).

The prevalence of pathologic conditions in the 12 normal contralateral hips is also summarized in Table II. The number of contralateral normal hips presenting with both FAI and DDH was 8/12 (66.67%). The number contralateral normal hips presenting with coxa profunda was 10/12 (83.33%), and no hips presented with protrusio acetabuli. Three of the 12 hips (33.33%) had fair joint congruity, 8 (66.7%) had good joint congruity, and 1 (8.3%) had excellent joint congruity.

Radiographic measurements for the hips presenting with a positive ptosis sign, contralateral hips presenting with no ptosis sign, and accepted range of values for normal hips are summarized in Table III. All radiographic parameters fell within the range of accepted values for normal hips except the femoral head extrusion index for both ptosis hips and non-ptosis hips, and the Sharp angle for all ptosis hips, but not unaffected hips. Both mean values of

Table III. Radiographic measurements of hips with positive ptosis sign and hips with no ptosis sign compared with accepted values in normal hips

	Positive ptosis sign all hips (n = *94*)	*No ptosis sign hips* (n = *12*)	P-*value*
Radiograph parameter	*Observed (mean ± SD)*	*Observed (mean ± SD)*	
Shenton's line break down (mm)	8.175 ± 2.431	2.71 ± 1.43	<0.00001
Acetabular index of depth to width (D/W)	53.72% ± 4.91%	53.58% ± 6.41%	0.929
Lateral subluxation (L) (mm)	7.984 ± 2.42	8.75 ± 2.19	0.300
Peak to edge distance (D) (mm)	20.11 ± 2.58	19.83 ± 2.82	0.727
True acetabular depth (mm)	10.52 ± 1.83	11.29 ± 2.15	0.181
M–Z distance (mm)	3.31 ± 2.38	3.58 ± 1.86	0.706
ACM angle	42.94 ± 3.38	43.0 ± 3.63	0.954
Center-edge angle	29.29 ± 5.36	27.71 ± 8.44	0.373
Sharp angle	37.53 ± 3.81	40.71 ± 3.99	0.009
Tonnis angle	6.60 ± 4.84	8.21 ± 4.76	0.280
Femoral head radius female (mm)	26.18 ± 2.08	26.18 ± 2.08	>0.999
Femoral head radius male (mm)	29.30 ± 1.58	29.30 ± 1.58	>0.999
Superior head neck offset (mm)	9.89 ± 1.88	10.95 ± 2.1	0.072
Inferior head neck offset (mm)	8.88 ± 1.65	9.17 ± 2.12	0.580
Femur neck length (mm)	39.52 ± 5.56	39.96 ± 4.04	0.792
Femur neck width	37.67 ± 3.93	37.5 ± 5.03	0.892
Neck shaft angle	126.93 ± 4.67	127.46 ± 6.18	0.722
Alpha angle	49.75 ± 15.77	53.77 ± 19.09	0.419
Sphericity index of the femoral head	52% ± 3.9%	50.28% ± 9.6%	0.248
Extrusion index of the femoral head	13.27% ± 6.47%	14.66% ± 7.61%	0.494

the femoral head extrusion index for ptosis hips and non-ptosis hips fell below the cutoff value for acetabular over-coverage, and the Sharp angle for ptosis hips fell below the cutoff value for acetabular over-coverage.

Radiographic parameters were compared between hips with a positive ptosis sign and contralateral normal hips (Table IV) (Fig. 2). Hips with a positive ptosis sign had 1.05 mm less lateral subluxation ($P = 0.012$), 1.54 mm smaller distance of acetabular opening ($P = 0.005$), 2.28° greater center-edge angle ($P = 0.046$), 2.59° smaller Sharp angle ($P = 0.011$), 0.76 mm smaller femoral head radius (0.014), 0.86mm less inferior head–neck offset ($P = 0.049$), 2.49% smaller extrusion index ($P = 0.016$) and 0.52 mm smaller distance between femoral head centers ($P = 0.013$). Radiographic measurements of general hip morphology for ptosis patients according gender are summarized in Table V.

There was almost perfect agreement ($r > 0.80$) between observers for all radiographic parameters, except femoral head sphericity index, which had substantial agreement ($0.80 > r > 0.61$), and height of pelvis left, which had moderate agreement ($0.60 > r > 0.41$) (Table VI).

DISCUSSION

The development of osteoarthritis is multifactorial with many risk factors [14]. The preservation of the hip joint requires perfect congruency between the femoral head and the acetabulum. Alterations in joint congruency may affect the biomechanics of the hip and may eventually lead to OA of the hip.

Table IV. Comparison of radiologic parameters in patients with one hip with positive ptosis sign and one hip without a ptosis sign

	Positive ptosis sign unilateral hips (n = 12) (Mean ± SD)	*Contralateral hips with no ptosis sign (n = 12) (Mean ± SD)*	P-*value*
Shenton's line break down (mm)	8.67 ± 2.26	2.71 ± 1.43	NA
Acetabular index of depth to width (*D*/*W*)	54.60% ± 5.30%	53.58% ± 6.41%	0.663
Lateral subluxation (*L*) (mm)	7.54 ± 2.52	8.75 ± 2.19	0.012
Peak to edge distance (*D*) (mm)	19.83 ± 1.76	19.83 ± 2.82	0.898
Distance of acetabular opening (*A*–*B* distance) (mm)	62.13 ± 6.42	63.75 ± 6.6218	0.005
True acetabular depth (mm)	11.71 ± 1.52	11.29 ± 2.15	0.344
M–*Z* distance (mm)	3.13 ± 1.65	3.58 ± 1.86	0.167
ACM angle	42.42 ± 2.06	43.0 ± 3.63	0.121
Center-edge angle	29.92 ± 3.51	27.71 ± 8.44	0.046
Sharp angle	38.13 ± 4.19	40.71 ± 3.99	0.011
Tonnis angle	4.58 ± 4.49	8.21 ± 4.76	<0.00001
Femoral head radius (mm)	26.29 ± 2.35	27.04 ± 2.37	0.014
Superior head neck offset (mm)	9.70 ± 2.74	10.95 ± 2.1	0.069
Inferior head neck offset (mm)	8.38 ± 1.66	9.17 ± 2.12	0.049
Femur neck length (mm)	40.42 ± 5.32	39.96 ± 4.04	0.743
Femur neck width (mm)	37.38 ± 4.29	37.5 ± 5.03	0.483
Neck shaft angle (mm)	127.79 ± 4.20	127.46 ± 6.18	0.978
Sphericity index of femoral head	51.00% ± 3.82%	50.28% ± 9.6%	0.947
Extrusion index	12.97% ± 3.99%	14.66% ± 7.61%	0.016
Distance between teardrops (mm)	139.04 ± 8.40	139.38 ± 8.22	0.339
Distance between femoral head centers (mm)	214 ± 14.15	214.54 ± 13.88	0.013
Distance between ischial tuberosities (mm)	110.42 ± 22.10	111.13 ± 22.63	NA
Height of pelvis right (mm)	243.55 ± 21.13	239.25 ± 24.07	NA
Height of pelvis left (mm)	245.77 ± 21.61	246.23 ± 21.41	0.073

This study demonstrates the presence of a positive ptosis sign in some patients undergoing femoroacetabular osteoplasty. The normal observed mean values of the lateral center-edge angle and Tonnis angle for all ptosis hips is reflective of the presence of both DDH and FAI in the patient population.

This radiographic analysis begins to characterize the ptosis phenomenon. The mean superior head–neck offset, inferior head–neck offset and alpha angle for all ptosis hips fell within the ranges of accepted values for normal hips, indicating that a positive ptosis sign is not a phenomenon explained by the presence of a cam deformity. In addition,

Table V. Comparison of radiographic parameters of general hip morphology between females and males

Parameter	*Female (mean ±SD) (n = 39)*	*Male (mean ± SD) (n = 14)*	P-*value*
Distance of acetabular opening (*A*–*B* distance) (mm)	60.44 ± 5.4	67.91 ± 5.61	<0.00001
M point	30.31 ± 2.74	34.08 ± 2.88	<0.00001
Femur neck length (mm)	38.78 ± 5.21	41.75 ± 5.39	0.076
Femur neck width (mm)	36.17 ± 3.3	41.8 ± 2.94	<0.00001
Neck shaft angle (mm)	127.19 ± 4.82	126.45 ± 4.95	0.627
Distance *b*/*t* two tear drops (mm)	138.24 ± 9.35	130.79 ± 5.58	0.007
Distance *b*/*t* two head centers (mm)	212.14 ± 15.24	215.11 ± 10.46	0.504
Distance *b*/*t* ischial tuberosities (mm)	116.81 ± 16.54	103.12 ± 13.39	0.008
Height of pelvis right (mm)	232.05 ± 14.0	260 ± 45.2	0.001
Height of pelvis left (mm)	234.78 ± 14.79	254.69 ± 13.43	<0.00001

the mean femoral head radius of both males and females, as well as the mean femoral head sphericity index for all ptosis hips were not significantly different from the accepted values for a normal femoral head, indicating that a positive ptosis sign cannot be explained by a malformed femoral head. The mean observed neck-shaft angle for all ptosis hips also fell within the accepted range for normal hips, indicating that an abnormal neck-shaft inclination does not explain the break down in Shenton's Line. The low prevalence of coxa valga and coxa vara in ptosis hips, as well as similar prevalence of coxa valga and coxa vara between unilateral ptosis hips and contralateral normal hips, further supports this conclusion.

We found evidence suggesting some degree of association between either acetabular over-coverage or a deepened acetabulum with a positive ptosis sign. One variable that could describe the ptosis phenomenon is the observed high prevalence of coxa profunda (70.2%) in ptosis patients. Coxa profunda describes a relatively deep acetabulum where the acetabular fossa touches or is medial to the ilioischial line on AP pelvic radiographs [9], and is a known risk factor for the development of FAI [15, 16]. It typically has been associated with acetabular over-coverage, particularly pincer type FAI [2]. The high percentage of female patients with a positive ptosis sign (73.6%) might be explained by the fact that Coxa profunda is a condition significantly associated with females [17].

Other parameters that characterize the ptosis phenomenon are the low mean extrusion index and low Sharp angle in all positive ptosis sign hips compared with normal values, and the relatively long femoral neck in ptosis hips. A reduced extrusion index and reduced Sharp angle are both indications of acetabular over-coverage. The significantly increased center-edge angle of ptosis hips compared with contralateral normal hips, significantly decreased Sharp angle of ptosis hips compared with contralateral normal hips and the significantly decreased Tonnis angle of ptosis hips compared with contralateral normal hips further supports the notion of underlying acetabular over-coverage. It is possible that the relatively long femoral neck and/or deepened acetabulum medially (coxa profunda) in many of these patients could explain the reduced extrusion index of the femoral head. Furthermore, the significantly reduced lateral subluxation of unilateral ptosis hips compared with contralateral normal hips ($P = 0.012$) indicates a femoral head situated deeper within the acetabulum. Due to the high prevalence of coxa profunda and the reduced extrusion index observed in ptosis hips, it is possible that ptosis sign could be an indication of pincer type impingement in some cases. In addition, the high percentage of female ptosis patients (73.6%) with an average age of 36.4 years is consistent with the percentage of pincer impingements in females (75%) and average age of 40 years [18]. Additional studies determining the prevalence of a positive ptosis sign in pincer type FAI patients would be needed to support this hypothesis. Recent studies also argue that coxa profunda is a nonspecific finding that is seen commonly in classic hip dysplasia [17, 19]. Due to the high prevalence (75.5%) of coxa profunda in the normal population [17], it is possible that a positive ptosis sign is also

Table VI. Inter-observer bias of radiographic measurements

Parameter	r
Acetabular index of depth to width (D/W)	0.851
Lateral subluxation (L)	0.915
Peak to edge distance (D)	0.924
Distance of acetabular opening (A–B distance)	0.952
M point	0.904
True acetabular depth	0.932
M–Z distance	0.960
ACM angle	0.992
Center-edge angle	0.976
Sharp angle	0.931
Tonnis angle	0.986
Femoral head radius	0.953
Superior head neck offset	0.800
Inferior head neck offset	0.913
Femur neck length	0.986
Femur neck width	0.982
Neck shaft angle	0.962
Sphercity index of femoral head A/B	0.782
Extrusion index A/B	0.926
Distance between two tear drops	0.964
Distance between 2 head centers	0.996
Distance between ischial tuberosities	0.992
Height of pelvis right	0.450
Height of pelvis left	0.997

commonly seen in normal, asymptomatic hips. Researchers may explore this issue in future studies.

The high prevalence of fair joint congruity (52.1%) in ptosis hips could suggest eventual joint space deterioration [12]. Standing AP pelvic radiographs would better evaluate the joint space. It would be beneficial to explore the potential causal relationship between a positive ptosis sign and eventual OA in future longitudinal studies, as a positive ptosis sign could be a key sign of early OA, just as a break up in Shenton's Line is a significant early sign of OA in DDH patients [3–5].

A limitation of this study is the small sample size of non-ptosis control hips to compare with the ptosis hips. No causal relationships could be drawn from this study due to a lack of longitudinal observation. The retrospective nature of this study also limits its strength. Furthermore, patients were only selected who were underwent one operation, FAO. As a result, this study could reflect a very narrow proportion of the ptosis patient population.

Further characterization and investigation of a positive ptosis sign on AP pelvic radiographs is required. While neither a correlation nor causation between a positive ptosis sign and osteoarthritis is currently possible, other conditions known to lead to OA, such as FAI and DDH, sometimes present with a positive ptosis sign. In addition, there is evidence that a positive ptosis sign may reflect a deepened acetabulum or acetabular over-coverage, or both. Further research is needed to explore a potential correlation between a positive ptosis sign and OA, as well as the prevalence of a positive ptosis sign with FAI and DDH in a larger population.

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CONFLICT OF INTEREST STATEMENT

None declared.

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