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Coxa Profunda Is Not a Useful Radiographic Parameter for Diagnosing Pincer-Type Femoroacetabular Impingement

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Background: Coxa profunda is commonly viewed as a radiographic parameter that is indicative of pincer-type femoroacetabular impingement, and this finding can impact diagnostic and surgical decision-making. Validation of coxa profunda as a measure of pincer-type femoroacetabular impingement has not been rigorously analyzed. Our hypothesis was that coxa profunda is a very common radiographic finding in females and is not a finding that is specifically associated with pincer-type femoroacetabular impingement.

Methods: A retrospective review was performed to determine the prevalence of coxa profunda in four groups of hips: those with acetabular dysplasia (fifty-eight hips), femoroacetabular impingement (fifty hips), symptomatic residual Legg-Calvé-Perthes deformities (sixteen hips), and asymptomatic hips (thirty-three). Coxa profunda was present when the floor of the acetabular fossa touched or was medial to the ilioischial line. The association between coxa profunda and hip disorder diagnosis, lateral center-edge angle, acetabular inclination, patient age, and sex was analyzed.

Results: Coxa profunda was seen in 55% of the 157 hips and was slightly less common in the hips with acetabular dysplasia or residual Legg-Calvé-Perthes deformities (41% and 31%, respectively). Coxa profunda was evident in 76% of the thirty-three asymptomatic hips compared with 64% of the fifty hips with femoroacetabular impingement. Coxa profunda was more common in females than males (70% compared with 24%; $p < 0.001$). Acetabular overcoverage (a lateral center-edge angle of $>40^\circ$ or acetabular inclination of $<0^\circ$) was seen in only 22% of hips with coxa profunda.

Conclusions: Coxa profunda should be considered a normal radiographic finding, at least in females. Coxa profunda is a nonspecific radiographic finding, seen in a variety of hip disorders and asymptomatic hips. The presence of coxa profunda is neither necessary nor sufficient to support a diagnosis of pincer-type femoroacetabular impingement.

Level of Evidence: Prognostic Level III. See Instructions for Authors for a complete description of levels of evidence.

The refined understanding of femoroacetabular impingement as a source of hip pain in the young adult has dramatically changed the evaluation and treatment of these patients¹⁻³. Accurate diagnosis relies heavily on clinical history, physical examination, and radiographic evaluation^{1,2,4,5}. Radiographic evaluation plays a role in supporting the clinical diagnosis and in identifying and differentiating among subtypes of femoroacetabular impingement. Cam, pincer, and combined types of femoroacetabular impingement can occur². Accurate identification of hip pathomechanics is important as

this may alter the diagnosis, preoperative planning, and surgical decision-making related to the treatment of prearthritic hip disorders.

Pincer-type femoroacetabular impingement is characterized by a repetitive impaction type of injury between the prominent acetabular rim and the femoral head-neck region². This type of impingement can occur as a result of several distinct structural abnormalities, including acetabular retroversion, focal anterosuperior overcoverage, or global acetabular overcoverage. Radiographic parameters of pincer-type femoroacetabular

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impingement are evaluated on anteroposterior pelvic radiographs. Parameters reported in the literature are variable and include the crossover sign, ischial spine sign, posterior wall sign, lateral center-edge angle, acetabular index, acetabular rim osseous apposition, acetabular protrusion, and coxa profunda^{4,6}. Among these parameters, coxa profunda has the least documented validation. Coxa profunda is defined as being present when the floor of the acetabular fossa touches or is medial to the ilioischial line^{4,7}. In distinction, acetabular protrusion is present when the femoral head projects medial to the ilioischial line. A hip with coxa profunda is classically referred to as a “deep hip” or “deep socket.”⁸ Alternative definitions of coxa profunda based on quantitative parameters (generally the lateral center-edge angle) have occasionally been utilized in the literature and are a source of confusion. Clearly, there is a need to better characterize the clinical importance of coxa profunda and the association of this finding with femoral head coverage.

It is our clinical impression that coxa profunda is not a useful marker of pincer-type femoroacetabular impingement because we commonly observe this finding in a wide variety of hip disorders as well as in patients without hip pathology. Additionally, we have noted this finding to be particularly common in females. The purpose of the present study was to determine the prevalence of coxa profunda in (1) hips with acetabular dysplasia, (2) hips with femoroacetabular impingement (all subtypes), (3) hips with symptomatic residual Legg-Calvé-Perthes deformities, and (4) asymptomatic hips. Additionally, we investigated the association of coxa profunda with the lateral center-edge angle, acetabular inclination, and patient age and sex.

Materials and Methods

We performed a retrospective review of anteroposterior pelvic radiographs of 157 patients (157 hips) to determine the prevalence of coxa profunda in four different subgroups. The four subgroups included (1) hips with acetabular dysplasia (fifty-eight), (2) hips with symptomatic femoroacetabular impingement (fifty), (3) hips with residual Legg-Calvé-Perthes deformities (sixteen), and (4) a comparison group of asymptomatic hips (thirty-three). The study was approved

by the institutional review board at our institution. The comparison group of asymptomatic hips has been previously described⁹. These patients were evaluated in clinic by one of the senior authors (J.C.C.) after the completion of hip radiographs. Nevertheless, after a complete history and physical examination, the patients had no symptoms consistent with hip pathology. All of the patients presented with back or leg pain and had no evidence of intra-articular hip disease. None of the patients had evidence of hip irritability on examination, and none had a positive impingement sign. All patients had signs and symptoms of disorders not involving the hip. The other patient cohorts were established by searching our hip preservation surgery database (February 2008 to February 2011). Diagnoses were established on the basis of clinical history, physical examination, and radiographic findings by one of the senior authors, with extensive experience treating prearthritic hip disease, including dysplasia, femoroacetabular impingement, and residual Legg-Calvé-Perthes deformities^{3,10}. The subtype of femoroacetabular impingement (cam, pincer, or combined) was determined by one of the senior authors. Radiographic findings of coxa profunda were not considered indicative of any diagnosis. Consecutive surgical patients with symptomatic acetabular dysplasia undergoing periacetabular osteotomy, those with symptomatic femoroacetabular impingement (any type) undergoing arthroscopy or open surgical dislocation, and those with residual Legg-Calvé-Perthes deformities undergoing open surgical dislocation with or without periacetabular osteotomy were included. Subtypes of femoroacetabular impingement included cam type (72%; thirty-six of fifty hips), pincer (2%; one hip), and combined (26%; thirteen hips). For analysis, subtypes of femoroacetabular impingement were grouped into femoroacetabular impingement with (fourteen hips) and without (thirty-six hips) a component of pincer-type femoroacetabular impingement. Hips with residual Legg-Calvé-Perthes deformities were included because of the common difficulty in distinguishing underlying etiology between instability and impingement in these patients¹¹. Patients with a history of previous pelvic osteotomy or substantial osteoarthritis (a Tönnis grade¹² of ≥ 2) were excluded. Anteroposterior pelvic radiographs were performed with the patient in the supine position with 15° of internal rotation of the lower extremities according to a standardized protocol previously described⁴. The radiograph tube-to-film distance was 120 cm. The x-ray beam was perpendicular to the x-ray table and centered midway between the superior border of pubic symphysis and anterior superior iliac spines. Patient diagnosis, age, and sex were recorded.

Radiographic evaluation of coxa profunda was performed by a single individual (J.J.N.) with experience in the radiographic evaluation of the young adult hip but not involved in the clinical care of the patients. Coxa profunda was defined as present when the floor of the acetabular fossa touched or was medial to the ilioischial line^{4,7} (Figs. 1, 2, and 3). Radiographic analysis was performed with the evaluator blinded to the diagnosis, age, and sex of the patient.



Fig. 1
An example of an asymptomatic hip without coxa profunda in the control group demonstrating the medial acetabular fossa (blue) and ilioischial line (red).



Fig. 2
An example of a dysplastic hip with coxa profunda demonstrating the medial acetabular fossa (blue) touching the ilioischial line (red).

However, the complete anteroposterior pelvic radiograph was reviewed, which in some cases would allow the diagnosis to be inferred. The intraobserver and interobserver reliability of determination of coxa profunda was assessed using a subset of twenty radiographs (including hips from all four cohorts) and one additional reader (J.C.C.). Intraobserver and interobserver reliability was perfect (kappa of 1.0). Coxa profunda was also assessed in the contralateral hip ($n = 150$), with seven contralateral hips being excluded because of prior surgery.

Measurements of the lateral center-edge angle¹³ and acetabular inclination¹² were performed by the same individual (J.J.N). Both measurements utilized a horizontal reference between the inferior aspects of the ischial tuberosities. The lateral center-edge angle was defined as the angle between a line perpendicular to the horizontal reference through the center of the femoral head and a line connecting the femoral head center to the most lateral aspect of the acetabular sourcil. The acetabular inclination was defined as the angle between the horizontal reference and a line connecting the most lateral and medial aspects of the sourcil. The intraobserver and interobserver reliability of the lateral center-edge angle and acetabular inclination has been previously shown to be excellent^{14,15}.

Analysis of the association of coxa profunda with other parameters of excessive acetabular coverage was performed on the combined normal and femoroacetabular impingement subgroups. A lateral center-edge angle of $>40^\circ$ and acetabular inclination of $<0^\circ$ were defined as acetabular overcoverage^{4,6,16}.

A power analysis was performed for the primary comparison of interest (femoroacetabular impingement group versus comparison group). For a large effect size, an alpha of 0.05, and a power of 0.9, forty-three subjects were required between the two groups combined. Statistical analysis was performed using the chi-square test, Fisher exact test, or Mann-Whitney U test.

Source of Funding

Funding for the study included the Curing Hip Disease Fund and NFL Charities Grant. The funding sources played no role in the investigation.

Results

Table I summarizes the demographic data for each cohort. Overall, 68% of the 157 patients were female. Female patients were more common than males in all but the cohort with residual Legg-Calvé-Perthes deformities. The average age of the patients in the study was 30.5 years (range, 13.7 to 50.9 years). The cohort with residual Legg-Calvé-Perthes deformities tended to be slightly younger, while the asymptomatic cohort was slightly older.



Fig. 3
An example of an asymptomatic control hip with coxa profunda demonstrating the medial acetabular fossa (blue) projecting medial to the ilioischial line (red).

TABLE I Demographics of Cohorts

Cohort	Description	No. of Hips	No. of Hips in Female Patients	Mean Age (yr)
1	Dysplasia	58	41 (71%)	28.1
2	Femoroacetabular impingement	50	36 (72%)	30.7
3	Residual Legg-Calvé-Perthes deformities	16	5 (31%)	23.0
4	Asymptomatic	33	24 (73%)	38.2
Combined		157	106 (68%)	30.5

TABLE II Prevalence of Coxa Profunda by Cohort and Sex

Cohort	Description	Hips with Coxa Profunda			Comparison of Male and Female Patients (<i>p</i> value)
		All Hips (%)	Females (%)	Males (%)	
1	Dysplasia	41	56	6	<0.001
2	Femoroacetabular impingement	64	78	29	0.001
3	Residual Legg-Calvé-Perthes deformities	31	40	27	0.610
4	Asymptomatic	76	88	44	0.010
Combined		55	70	24	<0.001

Coxa profunda was seen in 55% (eighty-six) of all 157 hips. Coxa profunda was less common in the cohort with dysplasia (41%; twenty-four of fifty-eight hips; $p = 0.002$) and the cohort with residual Legg-Calvé-Perthes deformities (31%; five of sixteen hips; $p = 0.003$) than in the comparison group (76%; twenty-five of thirty-three hips). Coxa profunda was evident in 64% (thirty-two) of fifty hips with femoroacetabular impingement, which did not differ significantly from the comparison group ($p = 0.258$). Coxa profunda was much more common in females (70%; seventy-four of 106 hips) than males (24%; twelve of fifty-one hips) ($p < 0.001$). For the entire cohort, coxa profunda was three times more likely in females (95% confidence interval [CI]: 1.8, 4.9) than males. This was true for each cohort (Table II). Coxa profunda was seen in 88% of females in the comparison group compared with 44% of males in this group. Coxa profunda was seen in 78% of females with femoroacetabular impingement and 29% of males with femoroacetabular impingement. Coxa profunda was seen in 79% (eleven) of fourteen hips with pincer-type or combined femoroacetabular impingement compared with 58% (twenty-one) of thirty-six hips with isolated cam-type femoroacetabular impingement. This difference was not significant ($p = 0.181$). No significant association between age and the presence of coxa profunda was observed ($p = 0.152$). Patients with coxa profunda were an average of 31.6 years old compared with patients without coxa profunda who were an average of 29.2 years old.

In the entire cohort, 5% (four) of eighty-six hips with coxa profunda had a lateral center-edge angle of $>40^\circ$ and 21% (eighteen) had an acetabular inclination of $<0^\circ$. Of all eighty-six hips with coxa profunda, only 22% (nineteen) had evidence of acetabular overcoverage (a lateral center-edge angle of $>40^\circ$ and/

or acetabular inclination of $<0^\circ$). Among the asymptomatic and femoroacetabular impingement cohorts combined, the median lateral center-edge angle of hips with coxa profunda was 29.7° compared with 28.4° for hips without coxa profunda ($p = 0.569$) (Table III). Similarly, the median acetabular inclination of hips with coxa profunda was 2.7° compared with 2.9° for hips without coxa profunda ($p = 0.579$). A lateral center-edge angle of $>40^\circ$ was found in 5% (three) of fifty-seven hips with coxa profunda and 4% (one) of twenty-six hips without coxa profunda. An acetabular inclination of $<0^\circ$ was seen in 30% (seventeen) of fifty-seven hips with coxa profunda and 19% (five) of twenty-six hips without coxa profunda ($p = 0.310$). Acetabular overcoverage (a lateral center-edge angle of $>40^\circ$ or acetabular inclination of $<0^\circ$) was present in 30% of hips with coxa profunda and 19% of hips without coxa profunda ($p = 0.310$). Table III shows the measurements of acetabular coverage by group.

The presence of coxa profunda was highly associated between the index, or affected, hip and the contralateral hip ($p < 0.001$). Of the eighty-three patients with coxa profunda in the affected hip, seventy-one (86%) had evidence of coxa profunda in the contralateral hip. Of the sixty-seven patients without coxa profunda in the affected hip, forty-six (69%) had no evidence of coxa profunda in the contralateral hip. Specifically in the femoroacetabular impingement group, coxa profunda in one hip was highly associated with evidence of it in the contralateral hip ($p < 0.001$). Among the thirty-two patients (thirty-two hips) in the femoroacetabular impingement group with coxa profunda, twenty-nine (91%) had evidence of coxa profunda in the contralateral hip. Among the eighteen patients (eighteen hips) in the femoroacetabular impingement group without coxa profunda, fifteen (83%) had no evidence of coxa profunda in the contralateral hip.

TABLE III Parameters of Acetabular Overcoverage

Coxa profunda	All Hips		Dysplasia		Femoroacetabular Impingement		Asymptomatic	
	Present	Absent	Present	Absent	Present	Absent	Present	Absent
No. of hips	86	71	24	34	32	18	25	8
Lateral center-edge angle								
Median (deg)	25.8	18.4	14.2	12.4	26.7	27.8	32.7	31.8
>40° (% of hips)	5	1	0	0	3	6	8	0
Acetabular inclination								
Median (deg)	7.1	14.7	18.2	20.2	2.4	2.6	4.0	7.3
<0° (% of hips)	21	7	0	0	38	22	20	13
Lateral center-edge angle of >40° or acetabular inclination of <0° (%)	22	7	0	0	38	22	20	13

Discussion

Coxa profunda, defined as the acetabular fossa touching or projecting medial to the ilioischial line, has been viewed as one of the findings associated with pincer-type femoroacetabular impingement since its original description². Beck et al.⁸ viewed coxa profunda as “typical of pincer impingement.” Prospective longitudinal studies demonstrating the long-term implications of coxa profunda have not been performed. Numerous authors have continued to view coxa profunda as evidence of pincer-type impingement^{6,8,17-29}. We also viewed this radiographic parameter as an indicator of femoroacetabular impingement⁴. The results of our study strongly question the clinical utility of coxa profunda as a radiographic marker of pincer-type femoroacetabular impingement.

Previous authors have questioned the clinical utility of coxa profunda^{30,31}, even before a refined understanding of femoroacetabular impingement. In 1978, Armbuster et al.³⁰ reported the results of a detailed study of radiographic anatomy pertaining to coxa profunda. They found the presence of the “acetabular line” crossing the ilioischial line (coxa profunda) to be strongly associated with sex, as it was seen in 71% of females compared with 19% of males. They also found it to be more common in individuals less than forty years old compared with older individuals. Additionally, the prevalence of coxa profunda in females has been shown to be approximately 50% in one large study³². In our study (combining cohorts), we found a prevalence of 70% in females and 24% in males. We did not observe a significant association between coxa profunda and age, although patients in our study tended to be younger. Only about 20% of our cohort was over the age of forty years.

Corten et al.¹⁷ investigated a cohort of 148 hips with femoroacetabular impingement and the association of coxa profunda with acetabular rim osseous apposition on radiographs and magnetic resonance imaging (MRI) scans. The authors implied that appositional bone growth at the acetabular rim is indicative of pincer-type femoroacetabular impingement. They found a 52% incidence of coxa profunda in

female patients with femoroacetabular impingement. They found osseous apposition in 29% of hips with coxa profunda compared with 8% of hips without coxa profunda. The authors concluded that coxa profunda is a useful parameter of pincer-type femoroacetabular impingement, except in “hips with a center-edge angle <20°,” although there was no control population for comparison. In our study, coxa profunda was common (41%) even in the most “shallow” hips being treated for symptomatic acetabular dysplasia. After excluding cohorts associated with acetabular dysplasia, the presence of coxa profunda was not strongly associated with other markers of acetabular overcoverage. Only about 30% of hips with coxa profunda in our study had other evidence of radiographic acetabular overcoverage.

There is variation in definitions of pincer-type femoroacetabular impingement in the literature. Femoroacetabular impingement is commonly subcategorized as cam, pincer, or combined types. The combined type of femoroacetabular impingement has been generally reported to be the most common⁸. However, many of these studies utilized coxa profunda as a marker of pincer morphology. The prevalence of coxa profunda in groups of patients with symptomatic femoroacetabular impingement has been reported to range from 14% to 58%^{8,18,20-25}. Given the results of the current study, if the presence of coxa profunda is interpreted as pincer-type femoroacetabular impingement, then nearly two-thirds of cam-type deformities would be classified as combined femoroacetabular impingement. Further research is indicated to better define the prevalence of femoroacetabular impingement subtypes, with the exclusion of coxa profunda as a diagnostic parameter. Allen et al.²⁰ previously reported a significantly higher lateral center-edge angle in hips with coxa profunda. In their study, hips with coxa profunda had a mean lateral center-edge angle of 38.7° (range, 29° to 56°) compared with those without coxa profunda or acetabular retroversion (mean lateral center-edge angle, 33.6°). Combining the femoroacetabular impingement group and comparison group, we found no significant difference in

lateral center-edge angle among hips with and without coxa profunda (mean, 30.1° and 29.2°, respectively). Similarly, no significant differences in acetabular inclination were detected.

Coxa profunda was seen in 76% of hips in the asymptomatic comparison group. However, the comparison group in our study may not represent a cohort of truly asymptomatic, so-called control patients, as they presented for clinical evaluation and had a radiographic hip series followed by a complete orthopaedic history and physical examination⁹. One of the senior authors (J.C.C.) evaluated these patients and thought there was no clinical evidence of intrinsic hip disease. Nevertheless, there exists the possibility that some of these patients could have had structural hip disease (femoroacetabular impingement or acetabular dysplasia) with an atypical clinical presentation. If this were the case, it would be in a small minority of these patients and unlikely to change the findings of the study. However, our control group does represent a group of patients without an abnormality of the hip who may present for possible hip pathology and undergo radiographs. In this sense, this group ideally represents patients in whom the presence of coxa profunda should not be overemphasized.

This study has limitations. First, pelvic tilt was not assessed as part of the radiographic analysis. The position of the sacrococcygeal joint and/or coccyx on the anteroposterior pelvic radiograph provides an estimate of pelvic tilt, although a true lateral radiograph of the sacrum is required for accurate determination of pelvic tilt^{33,34}. The effect of changes that pelvic tilt has on the appearance of coxa profunda is unknown. However, changes in pelvic tilt have a minimal effect on the measurement of the lateral center-edge angle and acetabular inclination³³. Additionally, the patient cohorts were established according to the diagnoses assigned by one of the senior authors. While misdiagnoses may have occurred, this author has extensive experience in the evaluation of prearthritic hip disease^{3-5,10}. Radiographic review was part of this clinical evaluation and is an additional potential source of bias. However, in determining the clinical diagnoses, the presence of coxa profunda alone was not viewed as consistent with femoroacetabular impingement. Additionally, only about one-third of the hips with femoroacetabular impingement had a pincer

component on the basis of the treating surgeon's assessment. Thus, the number of hips with femoroacetabular impingement and pincer-type morphology was somewhat limited. However, coxa profunda was common in this subgroup (79%), but a similar rate was also observed in the asymptomatic control group (76%). Finally, our study utilized the classic definition of coxa profunda, in which the acetabular fossa touches or is medial to the ilioischial line. Determination of whether the acetabular fossa touches the ilioischial line in subtle cases may be more subjective. This determination would influence the relative prevalence of these findings to some degree.

The presence of coxa profunda on anteroposterior pelvic radiographs has historically been considered an indicator of a "deep hip socket." The recent understanding of femoroacetabular impingement has led to the inclusion of coxa profunda as a marker of pincer-type deformity, with little validation. In light of our data, the presence of coxa profunda can be a normal finding. The presence of coxa profunda appears to have a very limited role in the radiographic identification of pincer-type deformity. Alternative parameters of pincer-type femoroacetabular impingement, including the crossover sign, posterior wall sign, lateral center-edge angle, anterior center-edge angle, and acetabular inclination, should be utilized collectively to assess femoral head overcoverage. Importantly, the final diagnosis and treatment decision-making for a given patient is derived from multiple factors including demographics, history, physical examination, radiographs, and advanced imaging (computed tomography and MRI). ■

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