

Retrospective Analysis of Idiopathic Hip Osteoarthritis Based on Anteroposterior Pelvic Radiograph; Hip Osteoarthritis Caused by Femoroacetabular Impingement

Miklos Papp,^{1*} Behzad Nadianmehr,² Gabor Bodo,³ Oliver Racz,⁴ Peter Molnar,⁵ and Zoltan Karolyi²

¹MD, PhD, Department of Orthopaedic Surgery, Borsod County Hospital Hungary, University of Miskolc, Faculty of Health Care, Hungary

²MD, Department of Orthopaedic Surgery, Borsod County Hospital, Hungary

³DVM, PhD, Head Equine Department and Clinic, Faculty of Veterinary Science, Szent Istvan University, Ullo, Hungary

⁴PhD, University of Miskolc, Faculty of Health Care, Hungary

⁵MD, Department of Orthopaedic Surgery, Hungarian Defense Forces Health Center and Military Hospital, Hungary

*Corresponding author: Miklos Papp, MD, PhD, Department of Orthopaedic Surgery, Borsod County Hospital Hungary, University of Miskolc, Faculty of Health Care, Hungary. Tel: +36-205616345, Fax: +36-46427106, E-mail: drpapp.miklos@gmail.com

Received 2015 December 16; Revised 2016 August 16; Accepted 2016 September 24.

Abstract

Background: Femoroacetabular Impingement (FAI) means pathological impact between the femoral head-neck junction and the acetabular rim.

Objectives: The aim of this retrospective study was to analyze Femoroacetabular Impingement (FAI) signs, which can lead to idiopathic hip osteoarthritis, from preoperative radiographs of patients indicated for total hip replacement as compared to radiographs of patients without this indication.

Methods: We examined the preoperative anteroposterior (AP) pelvic radiograph, the pincer and cam FAI signs of patients between 45 and 60 years, who had undergone total hip replacement. We examined in the same group, the operated side and the non-operated hips with osteoarthritis (patients group). In the control group we examined the pelvic radiograph of patients without symptoms between 45 and 60 years old (control, group).

Results: In the patient group (215 patients, 313 hips) we noted the signs of FAI in 88% while in the control group (112 patients 224 hips) these signs were found in 8.8% of cases.

Conclusions: In 88% of primary osteoarthritis cases we found FAI morphology on the AP pelvic radiograph, similarly to those found in the bibliography, and we considered naming primary osteoarthritis, secondary osteoarthritis caused by FAI. In the majority of cases, early diagnosis with simple, cheap and easily accessible AP pelvic radiograph with low dose of radiation may also be warranted

Keywords: Cam Femoroacetabular Impingement, Pincer Femoroacetabular Impingement, Mixed Femoroacetabular Impingement, Basic Signs of Femoroacetabular Impingement (Posterior Wall Sign, Csrossover Sign, Spina Ischiadica Sign, Flattened Femoral Head, Pistol Grip Deformity), Secondary Signs of Femoroacetabular Impingement

1. Background

Hip osteoarthritis is divided into two main categories. Secondary hip osteoarthritis is caused by different childhood or adult conditions (Table 1). Regardless of the age of the patients, trauma can lead to secondary hip osteoarthritis (1).

Hip osteoarthritis manifesting without these conditions is primary or idiopathic hip osteoarthritis (2, 3). In addition, the term idiopathic hip osteoarthritis from morphological point of view is restricted to cases with lateral center edge angle between 25 and 39 degrees (4, 5).

According to available data, idiopathic hip osteoarthritis is mostly caused by Femoroacetabular Impingement (FAI), which means there is a pathological impact between the femoral head-neck junction and the acetabular rim (2, 5-9). Femoroacetabular Impingement can be divided to

pincer and cam type. The cause of the pincer type is focal or general over coverage (cranial acetabular retroversion or coxa profunda) of femoral head by acetabulum, whereas the cause of cam type is aspheric femoral head or head-neck junction. The pincer type typically occurs in females between age 30 and 40 years in contrast to the cam type, which manifests typically in younger males. In a number of cases, signs of both types are present and they are classified as mixed type FAI (7, 10).

2. Objectives

The aim of this retrospective study was analysis of FAI signs associated with idiopathic hip osteoarthritis from preoperative anteroposterior radiographs of patients indicated for total hip replacement (the operated and also

Table 1. Reasons for Secondary Hip Osteoarthritis

Hip diseases in infancy or childhood that may lead to osteoarthritis	Hip diseases in adulthood that may lead to osteoarthritis
Hip dysplasia	Rheumatoid arthritis
Slipped capital femoral epiphyses	Lupus
Coxa vara	Ankylosing spondylitis
Coxa valga	Reiter's syndrome
Coxa vara infantum	Septic, tuberculous arthritis
	Tumors
	Fractures Around The Hip
	Osteonecrosis
	Calcium Pirophosphate Disease
	Gout
	Protrusio Acetabuli
	Coxa Profunda

the contralateral, non-operated hips with osteoarthritis) as compared to radiographs of patients without this indication (control group) and the radiographs of the patient's non-operated contralateral hips without osteoarthritis.

3. Methods

3.1. Patients

We examined the preoperative anteroposterior [AP] pelvic radiograph of 543 patients aged between 45 and 60 years, who had undergone total hip replacement between 2005 and 2012 at two different departments.

3.2. Exclusion Criteria

1. Evidence of hip conditions causing secondary osteoarthritis from personal history and patients' documentation; 2, lateral center edge $> 39^\circ$ or $< 25^\circ$ according to Tonnis (5) (over coverage) and Murphy (4) (hip dysplasia); the center of the femur head was determined using a spherical template. The lateral center edge angle was measured between the vertical line running through the center of the femoral head and the line connecting the center of the femoral head and the lateral aspect of sourcil [medially to calcified labrum and os acetabuli]; 3, positional problems, such as excessive pelvic tilt and/or rotation or bad quality radiograph picture. The increasing tilt and/or rotation of the pelvis substantially alter the signs of acetabular retroversion (5).

Due to the exclusion criteria listed above we excluded 328 patients from the patient group and 109 patients from the control group.

After exclusion, we examined the preoperative AP pelvic radiograph of 313 hips (215 patients) in the patient group. In the control group (patients from the outpatient clinics with knee conditions) we examined the AP pelvic radiographs of 224 hips (112 patients). In both groups the patients' age, gender, an body mass index (BMI) were also recorded.

In the patient group we examined the operated and also the contralateral, non-operated hips with osteoarthritis (grade 2 - 3 according to Tonnis (11)).

3.3. Radiological Technique

For correct diagnosis of FAI, an oriented AP pelvic radiograph is needed (12). We used the method of Siebenrock (13). The tube-to-film distance was 120 cm. The central X-ray beam was directed to the middle of the distance between the superior border of the symphysis and the horizontal line drawn through anterior iliac spines. The rotation of the hip can be excluded if the top of coccyx points to the center of symphysis, the acetabular teardrops and foramina, and the iliac wings are symmetrical (13). The tilting of pelvis is negligible, if the distance between the top of the coccyx and the superior border of the symphysis is less than 2 cm (14).

3.4. Analysis of the Basic and Secondary Signs of FAI

The basic signs of FAI are positive posterior wall, crossover, spina ischiadica as well as flattened femoral head and pistol grip deformity:

1, Posterior wall sign is positive if the line of the posterior wall is medial to the center of the femoral head (14). We quantified the posterior wall sign with the posterior

wall distance (12), that is the horizontal distance between the line of the posterior wall and the center of the femoral head; 2, crossover sign is positive if the line of the anterior wall is lateral to the line of the posterior wall cranially, then crossing with the line of the posterior wall runs medially to the posterior wall caudally (15). We quantified the crossover sign according to the acetabular retroversion index (14). This is a ratio of the distance between the crossing point of the anterior and posterior wall and the superolateral edge of the acetabulum to the distance between the superolateral edge of the acetabulum and the crossing point of the ischium and the posterior wall; 3, Spina ischiadica sign is positive if the spina ischiadica projects inside the acetabular rim (in triangular shape) (16). The spina ischiadica sign is quantified by the size of the projected spina measured in millimeters. The posterior wall sign, crossover sign and spina ischiadica sign indicate acetabulum retroversion (pincer type) (15, 16); 4, Flattened femoral head and pistol grip deformity. The pistol grip deformity is the flattening of the normally concave surface of the lateral aspect of the femoral head-neck junction. Both flattened head and pistol head grip deformity indicate the presence of cam deformity (15, 17, 18). The secondary signs of FAI are ossification of the labral basis (10), os acetabuli (15) and herniation pit (19).

Os acetabuli can be seen as a separated fragment from the surrounding bone; herniation pit is a 3- to 15-mm radiolucency surrounded by sclerotic margin in the femoral neck anterior proximal superior quadrant (Figure 1).

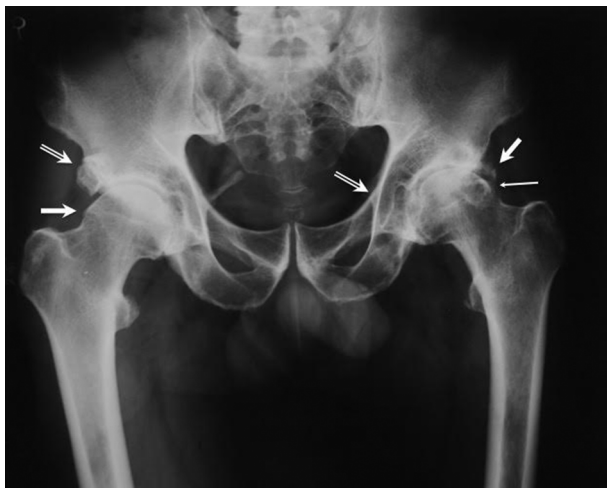


Figure 1. Anteroposterior Pelvic Radiograph; On the right side, the ossification of the sacrospinous ligament, os acetabuli (contoured arrow) and flattening of the head can be observed (thick arrow). On the left side the spina ischiadica sign (contoured arrow) cross-over sign and herniation pit (thin arrow) and labrum ossification (thick arrow) are indicated. The CEA is grade 38 on both sides.

3.5. Statistical Analysis

Statistical analysis was performed using the Student's t test and the Spearman rank order correlation test. P-values below 0.05 were considered significant. The study was approved by the independent research ethic committee.

4. Results

In the patients group we examined the preoperative AP pelvic radiographs of 313 hips. The average age of 107 males and 108 females was 52.2 ± 5.2 (range 45 - 60) years, and the average BMI was 28.0 ± 5.1 (range 17.8 - 44.1) kg/m^2 .

In the control group, we examined the AP pelvic radiograph of 224 hips (112 patients). The average age of 64 males and 48 females was 51.7 ± 3.7 (range 45 - 59) years, and the BMI was 27.1 ± 5.2 (range 18 - 43.1) kg/m^2 . There was no significant age and BMI difference between the patient and control groups.

In Table 2 the distribution of the FAI types and the secondary radiological signs are depicted. Table 3 indicates the distribution of FAI types as well as the secondary radiological signs according to gender. Table 4 shows the distribution of acetabular retroversion signs in the examined groups.

Table 2. Distribution of Femoroacetabular Impingement Types and Secondary Radiological Signs in Patient and Control Groups^a

N	Patient OA Group	Control Group
	313 (Hip)	(Hip)
Cam type	115 (36.7)	13 (5.8)
Acetabular retroversion	161 (51.4)	7 (3.1)
Pincer type	71 (22.6)	5 (2.2)
Mixed type	90 (28.7)	2 (0.8)
Labrum ossification	79 (25.2)	12 (5.3)
Os acetabuli	32 (10.2)	3 (1.3)
Herniation pit	14 (4.4)	10 (4.4)

^aValues are expressed as No. (%).

The mean posterior wall distance was 4.5 [2 - 8] mm. Considering the crossover sign of positive cases, the acetabular retroversion index in the patient group was 0.312 [0.15 - 0.66] while in the control group this was 0.211 [0.16 - 0.38]. In the presence of spina ischiadica sign, the size of projection of spina ischiadica in the acetabulum rim in the mentioned groups was 6.32 (20, 21) and 6.3 [3 - 8] mm.

Table 3. Distribution of Femoroacetabular Impingement Types and Secondary Radiological Signs According to Gender

	Distribution Of FAI Types And Secondary Radiological Signs According To Genders			
	Patient OA Group		Control Group	
	N = 313 (Hip)		N = 224 (Hip)	
	Man	Woman	Man	Woman
	N = 161	N = 152	N = 128	N = 96
Cam type	77	38	13	0
Acetabular retroversion	85	93	3	4
Pincer type	30	58	1	4
Mixed type	55	35	2	0
Labrum ossification	44	45	11	1
Os acetabuli	26	6	2	1
Herniation pit	10	4	8	2

Table 4. Distribution of ARV Signs

	Distribution of the ARV Signs	
	Patients OA Group	Control Group
	N = 313 (Hip)	N = 224 (Hip)
PWS alone	1	0
PWS + COS	10	0
PWS + COS + SIS	6	0
COS alone	70	1
Cos + SIS	91	6

5. Discussion

We considered the isolated presence of posterior wall sign positivity as a marker of posterior wall deficiency similarly to Giori (8) and Werner (22). A study of cadaver examinations by Jamali et al. (23) showed that crossover sign positivity is an indicator of cranial anteversion of < 4 degree and this is also in accordance with our observations.

We considered the combined presence of posterior wall sign and crossover sign cranial acetabular retroversion, with the note that the cause of crossover sign can also be the hypoplastic posterior wall itself.

According to Kalberer's (16) examinations, spina ischiadica sign is also an indicator of acetabular retroversion. We can confirm this significant correlation between crossover sign and spina ischiadica sign because we found crossover sign in every case when spina ischiadica sign was present. The simultaneous occurrence of crossover sign and spina ischiadica sign is a sign of true retroversion of the distal hemipelvis.

According to Werner (22), the combined presence of crossover sign, posterior wall sign and spina ischiadica sign is the most reliable indicator of acetabular retroversion. In our opinion the simultaneous presence of the crossover sign, the posterior wall sign and the spina ischiadica sign, can be an indicator of acetabular retroversion or posterior wall deficiency. In the patient group, posterior wall sign was recorded in 17 cases [5.4%]; in one case independently, which we considered as posterior wall deficiency, and in 16 cases with cam morphology (possible causative agent).

According to Ipach, Giori and Ezoë (3, 8, 24), the occurrence of the acetabular retroversion in control groups is 5% - 6% and in idiopathic hip osteoarthritis it is about 20%. In our study, these numbers were 3.1% and 51.4%, respectively. Similar to Tannast (10), the rate of pincer FAI in females was higher than males. Our results confirm this view; in the patient group, 38% were females and 18.6% males. Similar differences were found in the control group: 4.166% versus 0.7%.

The rate of a cam type in asymptomatic volunteers, according to Hack (25), was 14% and according to Malhotra (26) was 11.7%, while this was 5.8% in our control group. The Copenhagen Osteoarthritis study (27) found the cam morphology in 27.4% of males and 5.4% of females, while in our study these values were 47.9% and 25% in the patient group, respectively.

The occurrence rate of mixed type in the patient group, similar to previous reports (7), was 28.7%, it was substantially lower in the control group (0.8%).

According to the examinations of Cooke (20), the labrum ossification correlates with the cam type FAI; in our study the labrum ossification in the control group corre-

lated with cam [R = 0.25], and in the patients group with both the pincer and the cam FAI [R = 0.168, R = 0.249]. Ranawat (28), regarding diagnosed FAI found 18% herniation pits in males and 2% in females while we noted 6.2% and 2.6%, respectively.

In many aspects, our results differ from the data of previous studies. This can be caused by different factors, such as selection of patients and also ethnic factors.

To the best of our knowledge, three previous studies (3, 8, 24) examined, using conventional radiographs, the relationship between acetabular retroversion and primary osteoarthritis, but in the mentioned studies the patient and control groups were substantially different from each other.

From terminological point of view in agreement with Anderson (6) we suggest the use of the term secondary osteoarthritis caused by FAI instead of idiopathic hip osteoarthritis. Our opinion is based on the fact that in our study in 88% of patients, FAI morphology was present. Considering the weak point of our study (we did not examine by lateral radiograph the cam morphology, although we realized that for the diagnosis of cam type specialized lateral radiograph is necessary (28)) we assume that the rate of FAI is even higher.

According to the study of Jager (9) there is more than a five-year delay between the appearance of the symptoms and the diagnosis of labral tears caused by FAI, though the early recognition of FAI and well-performed operations hinder the development of osteoarthritis and the hip would not reach a stage requiring prosthesis (2, 21, 29).

Despite the fact that for objective measurement of acetabular retroversion, Computerized Tomography (CT) is needed (29) and for the diagnosis of labrum injury MR is needed (28), in the majority of cases, early diagnosis with simple, cheap, easily accessible AP pelvic radiograph with low dose of radiation can also be warranted and recommended.

Footnote

Financial Disclosure: There was no financial support.

References

- Tavakoli Darestani R, Kazemian G, Emami Moghaddam M, Manafi Rasi A, Alipour Y, Bagherian Lemraski MM. An unusual combination of acetabular and pelvic fracture: is this a new subtype of acetabular fracture?. *Trauma Mon.* 2013;**18**(1):37–40. doi: [10.5812/traumamon.9613](https://doi.org/10.5812/traumamon.9613). [PubMed: [24350148](https://pubmed.ncbi.nlm.nih.gov/24350148/)].
- Ganz R, Leunig M, Leunig-Ganz K, Harris WH. The etiology of osteoarthritis of the hip: an integrated mechanical concept. *Clin Orthop Relat Res.* 2008;**466**(2):264–72. doi: [10.1007/s11999-007-0060-z](https://doi.org/10.1007/s11999-007-0060-z). [PubMed: [18196405](https://pubmed.ncbi.nlm.nih.gov/18196405/)].
- Ipach I, Mittag F, Syha R, Kunze B, Wolf P, Kluba T. Indications for total hip arthroplasty in young adults - idiopathic osteoarthritis seems to be overestimated. *Rofjo.* 2012;**184**(3):239–47. doi: [10.1055/s-0031-1299052](https://doi.org/10.1055/s-0031-1299052). [PubMed: [22274871](https://pubmed.ncbi.nlm.nih.gov/22274871/)].
- Murphy SB, Ganz R, Muller ME. The prognosis in untreated dysplasia of the hip. A study of radiographic factors that predict the outcome. *J Bone Joint Surg Am.* 1995;**77**(7):985–9. [PubMed: [7608241](https://pubmed.ncbi.nlm.nih.gov/7608241/)].
- Tonnis D, Heinecke A. Acetabular and femoral anteversion: relationship with osteoarthritis of the hip. *J Bone Joint Surg Am.* 1999;**81**(12):1747–70. [PubMed: [10608388](https://pubmed.ncbi.nlm.nih.gov/10608388/)].
- Anderson SE, Siebenrock KA, Tannast M. Femoroacetabular impingement: evidence of an established hip abnormality. *Radiology.* 2010;**257**(1):8–13. doi: [10.1148/radiol.10091480](https://doi.org/10.1148/radiol.10091480). [PubMed: [20851934](https://pubmed.ncbi.nlm.nih.gov/20851934/)].
- Ganz R, Parvizi J, Beck M, Leunig M, Notzli H, Siebenrock KA. Femoroacetabular impingement: a cause for osteoarthritis of the hip. *Clin Orthop Relat Res.* 2003(417):112–20. doi: [10.1097/01.blo.0000096804.78689.c2](https://doi.org/10.1097/01.blo.0000096804.78689.c2). [PubMed: [14646708](https://pubmed.ncbi.nlm.nih.gov/14646708/)].
- Giori NJ, Trousdale RT. Acetabular retroversion is associated with osteoarthritis of the hip. *Clin Orthop Relat Res.* 2003(417):263–9. doi: [10.1097/01.blo.0000093014.90435.64](https://doi.org/10.1097/01.blo.0000093014.90435.64). [PubMed: [14646725](https://pubmed.ncbi.nlm.nih.gov/14646725/)].
- Jager M, Wild A, Westhoff B, Krauspe R. Femoroacetabular impingement caused by a femoral osseous head-neck bump deformity: clinical, radiological, and experimental results. *J Orthop Sci.* 2004;**9**(3):256–63. doi: [10.1007/s00776-004-0770-y](https://doi.org/10.1007/s00776-004-0770-y). [PubMed: [15168180](https://pubmed.ncbi.nlm.nih.gov/15168180/)].
- Tannast M, Siebenrock KA, Anderson SE. Femoroacetabular impingement: radiographic diagnosis—what the radiologist should know. *AJR Am J Roentgenol.* 2007;**188**(6):1540–52. doi: [10.2214/AJR.06.0921](https://doi.org/10.2214/AJR.06.0921). [PubMed: [17515374](https://pubmed.ncbi.nlm.nih.gov/17515374/)].
- Tonnis D. Congenital dysplasia and dislocation of the hip in children and adults. *Springer.* 1987:167.
- Hansen BJ, Harris MD, Anderson IA, Peters CL, Weiss JA, Anderson AE. Correlation between radiographic measures of acetabular morphology with 3D femoral head coverage in patients with acetabular retroversion. *Acta Orthop.* 2012;**83**(3):233–9. doi: [10.3109/17453674.2012.684138](https://doi.org/10.3109/17453674.2012.684138). [PubMed: [22553905](https://pubmed.ncbi.nlm.nih.gov/22553905/)].
- Siebenrock KA, Schoeniger R, Ganz R. Anterior femoro-acetabular impingement due to acetabular retroversion. Treatment with periacetabular osteotomy. *J Bone Joint Surg Am.* 2003;**85-A**(2):278–86. [PubMed: [12571306](https://pubmed.ncbi.nlm.nih.gov/12571306/)].
- Nehme A, Trousdale R, Tannous Z, Maalouf G, Puget J, Telmont N. Developmental dysplasia of the hip: is acetabular retroversion a crucial factor?. *Orthop Traumatol Surg Res.* 2009;**95**(7):511–9. doi: [10.1016/j.otsr.2009.06.006](https://doi.org/10.1016/j.otsr.2009.06.006). [PubMed: [19837022](https://pubmed.ncbi.nlm.nih.gov/19837022/)].
- Reynolds D, Lucas J, Klaue K. Retroversion of the acetabulum. A cause of hip pain. *J Bone Joint Surg Br.* 1999;**81**(2):281–8. [PubMed: [10204935](https://pubmed.ncbi.nlm.nih.gov/10204935/)].
- Kalberer F, Sierra RJ, Madan SS, Ganz R, Leunig M. Ischial spine projection into the pelvis : a new sign for acetabular retroversion. *Clin Orthop Relat Res.* 2008;**466**(3):677–83. doi: [10.1007/s11999-007-0058-6](https://doi.org/10.1007/s11999-007-0058-6). [PubMed: [18264856](https://pubmed.ncbi.nlm.nih.gov/18264856/)].
- McCarthy J, Noble P, Aluisio FV, Schuck M, Wright J, Lee JA. Anatomy, pathologic features, and treatment of acetabular labral tears. *Clin Orthop Relat Res.* 2003(406):38–47. doi: [10.1097/01.blo.0000043042.84315.17](https://doi.org/10.1097/01.blo.0000043042.84315.17). [PubMed: [12578998](https://pubmed.ncbi.nlm.nih.gov/12578998/)].
- Stulberg SL, Harris WH, Ramsey PL, MacEwen GD. Unrecognized childhood hip disease: a major cause of idiopathic osteoarthritis of the hip. *Mosby;* 1975.
- Pitt MJ, Graham AR, Shipman JH, Birkby W. Herniation pit of the femoral neck. *AJR Am J Roentgenol.* 1982;**138**(6):1115–21. doi: [10.2214/ajr.138.6.1115](https://doi.org/10.2214/ajr.138.6.1115). [PubMed: [6979213](https://pubmed.ncbi.nlm.nih.gov/6979213/)].
- Cooke WR, Gill HS, Murray DW, Ostlere SJ. Discrete mineralisation of the acetabular labrum: a novel marker of femoroacetabular impingement?. *Br J Radiol.* 2013;**86**(1021):20120182. doi: [10.1259/bjr.20120182](https://doi.org/10.1259/bjr.20120182). [PubMed: [23255539](https://pubmed.ncbi.nlm.nih.gov/23255539/)].

21. Kockara N, Bursali A, Issin A, Gursu SS, Yildirim T, Sahin V. [Is open surgery effective in early-term in patients with femoroacetabular impingement syndrome?]. *Ekleml Hastalik Cerrahisi*. 2012;**23**(2):72-6. [PubMed: [22765484](#)].
22. Werner CM, Copeland CE, Ruckstuhl T, Stromberg J, Turen CH, Kalberer F, et al. Radiographic markers of acetabular retroversion: correlation of the cross-over sign, ischial spine sign and posterior wall sign. *Acta Orthop Belg*. 2010;**76**(2):166-73. [PubMed: [20503941](#)].
23. Jamali AA, Mladenov K, Meyer DC, Martinez A, Beck M, Ganz R, et al. Anteroposterior pelvic radiographs to assess acetabular retroversion: high validity of the "cross-over-sign". *J Orthop Res*. 2007;**25**(6):758-65. doi: [10.1002/jor.20380](#). [PubMed: [17343286](#)].
24. Ezoe M, Naito M, Inoue T. The prevalence of acetabular retroversion among various disorders of the hip. *J Bone Joint Surg Am*. 2006;**88**(2):372-9. doi: [10.2106/JBJS.D.02385](#). [PubMed: [16452750](#)].
25. Hack K, Di Primio G, Rakhra K, Beaulé PE. Prevalence of cam-type femoroacetabular impingement morphology in asymptomatic volunteers. *J Bone Joint Surg Am*. 2010;**92**(14):2436-44. doi: [10.2106/JBJS.J.01280](#). [PubMed: [20962194](#)].
26. Malhotra R, Kannan A, Kancherla R, Khatri D, Kumar V. Femoral head-neck offset in the Indian population: A CT based study. *Indian J Orthop*. 2012;**46**(2):212-5. doi: [10.4103/0019-5413.93681](#). [PubMed: [22448061](#)].
27. Gosvig KK, Jacobsen S, Sonne-Holm S, Gebuhr P. The prevalence of cam-type deformity of the hip joint: a survey of 4151 subjects of the Copenhagen Osteoarthritis Study. *Acta Radiol*. 2008;**49**(4):436-41. doi: [10.1080/02841850801935567](#). [PubMed: [18415788](#)].
28. Ranawat AS, Schulz B, Baumbach SF, Meftah M, Ganz R, Leunig M. Radiographic predictors of hip pain in femoroacetabular impingement. *HSS J*. 2011;**7**(2):115-9. doi: [10.1007/s11420-010-9192-x](#). [PubMed: [22754409](#)].
29. Perreira AC, Laird T, Jamali AA. Multilevel measurement of acetabular retroversion using 3-D CT-generated models: implications for hip preservation surgery. *Clin Orthop Relat Res*. 2011;**2**(469):552-61.