Lo SCALPELLO Journal (2022) 36:95-99
doi number: 10.36149/0390-5276-259

Radiographic incidence of femoral acetabular impingement in young adults

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Summary

After Ganz's first work in 2003 on femoral acetabular impingement (FAI), the interest in this pathology has steadily increased. Several treatments have been proposed and many parameters have been evaluated to reach a diagnosis as accurate as possible. In fact, the resulting cartilage lesions are often associated with early development of osteoarthritis in symptomatic patients. Although there is a considerable percentage of elderly patients who meet radiographic criteria for FAI but are asymptomatic, this disease is commonly underestimated in young adults with coxalgia. The purpose of our study was to investigate these signs in radiographic images in patients under the age of 60 years who have undergone hip replacement surgery to see if FAI criteria were present. We found such signs in most of the patients examined. The most frequent type was mixed impingement. Diagnosis of FAI in symptomatic young adults, in the light of radiographic data, is likely to be underestimated. Early diagnosis and treatment therefore play a non-secondary role.

Key words: femoroacetabular impingement, FAI, hip, coxalgia, coxarthrosis

Received: May 25, 2022
Accepted: September 12, 2022

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How to cite this article: Barbati A, Pezzella R, Silleni F, et al. Radiographic incidence of femoral acetabular impingement in young adults. Lo Scalpello Journal 2022;36:95-99. https://doi.org/10.36149/0390-5276-259

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Introduction

After Ganz's first work [1] in 2003 on femoral acetabular impingement (FAI), the interest in this pathology has steadily increased. Several treatments have been proposed and many parameters have been evaluated to reach a diagnosis as accurate as possible. In fact, the resulting cartilage lesions are often associated with the early development of osteoarthritis in symptomatic patients. Although there is a considerable percentage of elderly patients who have radiographic criteria for FAI but are asymptomatic [2-5], this disease is commonly underestimated in young adults with coxalgia. The purpose of our study was to investigate these signs in radiographic images in patients under the age of 60 who have undergone hip replacement surgery to see if FAI criteria were present.

Etiology

By FAI it is implied that an impingement is created between the head of the femur and the acetabulum in certain movements. The maximum deformity is most frequently localized between 1 o'clock and 2 o'clock.

There are two main types of FAI. The first, called CAM (an acronym that recalls the camshaft of cars), is more common in young male athletes. It is usually due to the loss of the sphericity of the femoral head which creates the conflict against the acetabular rim, especially in flexion and internal rotation [6,7]. This causes injury to the acetabular cartilage which is separated from the labrum [8].

The second, termed Pincer, is more common in middle-aged athletic women. Pincer is due to the contact between the head-neck femoral junction and the acetabular rim. Chondral damage is located more circumferentially and usually includes only a narrow strip of acetabular cartilage. These anatomical alterations often coexist, which is referred to as mixed FAI.

Instrumental evaluation

Although some FAI-associated deformities have been described in the previous literature by Solomon and Schnitzler [9], Harris [10], Murray [11], and Stulberg et al. [12], referring to the development of osteoarthritis in gross and visible deformities (acetabular dysplasia, femoral pistol grip, head tilt), Ganz's study [1] specifically identified the conflict responsible for cartilage damage. Several parameters can be considered.

For CAM-type deformities we evaluated:

Alpha angle: was initially described in an MRI study by H. P. Nötzli [7] as a cause of early osteoarthritis in symptomatic patients. This parameter measures the angle at which the head loses its sphericity with respect to the axis of the femoral neck. The study involves a first coronal scan (scout) to identify the exact center of rotation of the femoral head and then axial cuts parallel to the neck where the alpha angle can be calculated. Later this technique was also adapted for traditional radiographs. Since most of the deformity is located in the anterosuperior portion of the head-neck junction, the best projections to evaluate the alpha angle are the axial ones, in particular Dunn's 45° and 90° projections (Fig. 1).

There is a fair amount of variability in the measurement of the alpha angle ranging from 42° to 63° [13,14]. This variability also takes into account the alpha point (point of loss of sphericity), which, according to some authors, should be considered 2 mm beyond [13]. The Copenhagen Osteoarthritis study identified sex-related variability [15].

Head-neck offset (HNO): in some patients, the deformity can be gradual with loss of offset between the head and the neck of the femur. This parameter is indicated as complementary to the measurement of the alpha angle. The measurement of this index, given by the difference in the distances between the straight-line tangent to the femoral neck and the one passing through its axis and the radius of the head, is pathological if it is less than 8 mm [16].

For Pincer type deformities, some parameters can be calculated directly on the AP radiographs [17] (lateral center-edge angle, ACM angle, sharp angle, acetabular and extrusion index and craniocaudal acetabular coverage), while others are influenced

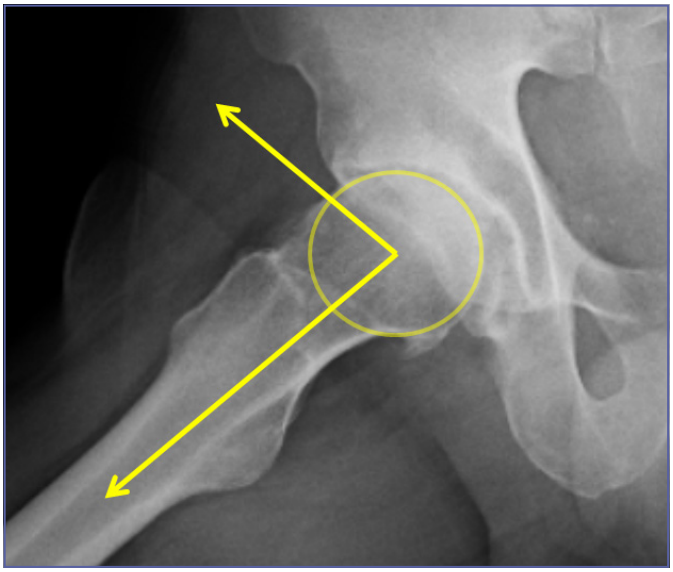

Figure 1. Evaluation of the alpha angle (frog leg).

by pelvic tilt and from the rotation of the pelvis for which it is necessary to first estimate this orientation to evaluate the congruence of the others [18]. While for the rotation of the pelvis it is sufficient to evaluate the symmetry of the obturator foramina [13] to calculate the pelvic tilt (angle formed by the horizontal line and the line that connects the upper edge of the symphysis with the sacral promontory), it is necessary to have a lateral projection [19]. However, there are indirect methods to assess pelvic tilt in AP projections using the distance between the upper edge of the pubic symphysis and the sacro-coccygeal joint [20]. A value from 1 to 3 cm is considered to be a normal circumstance.

If the pelvic tilt falls within normal parameters, it will be possible to evaluate the other factors. The following were examined in our study. As for the acetabulum version, we considered:

Cross over sign (Fig. 2): the line of the anterior and posterior margin of the acetabulum meets laterally to the acetabular roof in normal conditions, caudal to the roof in conditions of acetabular retroversion (a sign that is not easy to highlight) [21].

Retroversion Index: ratio between the distance of the acetabular profile, the cross over sign point, and the width of the acetabulum. Values > 33% indicate severe relative retroversion [22].

Posterior wall sign: it indicates poor coverage of the femoral head in the posterior region and may be seen on radiographs when the center of the femoral head is located lateral to the posterior wall. In normal conditions, the anterior wall falls in two-thirds of the head of the beam and the posterior wall coincides with the center of the head.

Ischial spine: another radiographic sign that suggests a retroversion of the acetabulum [23].

As for signs of global coverage of the acetabulum (Global Overcoverage), we considered:

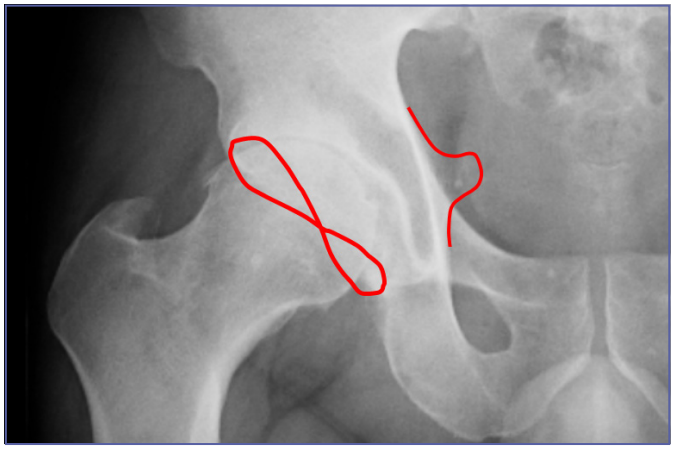

Figure 2. Cross-over sign and prominent ischial spine sign.

Wiberg angle [24] (Lateral center-edge angle): angle formed by the vertical line passing through the center of the femoral head and the one passing through the center and tangent to the lateral edge of the acetabulum. Values greater than 40° are pathological.
Coxa protusa (Fig. 3): The profile of the femoral head is medial to the ilio-ischial line. A non-indicative anatomic variant of FAI may occur in the case in which the medial acetabular fossa is tangent or medial to the ilio-ischial line (Coxa profunda) [25].

Materials and methods

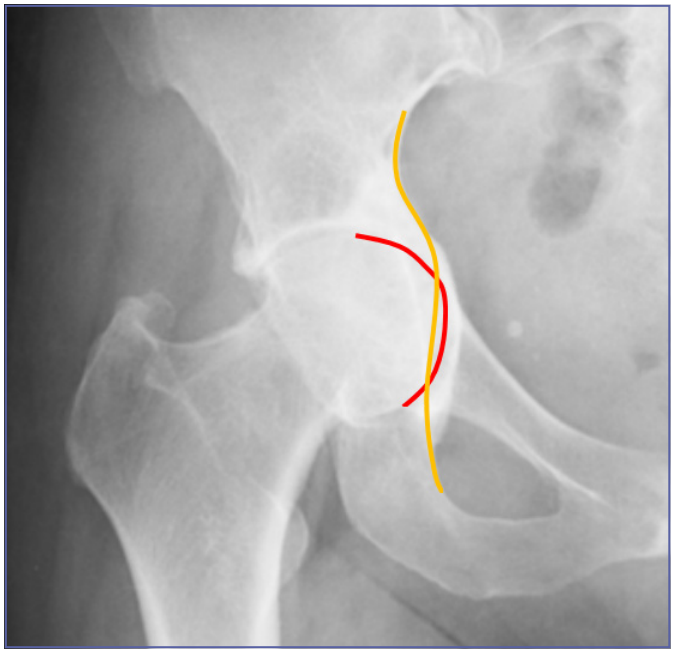

Figure 3. Coxa protrusa.

In the period between 2012 and 2018 in our Institution, a total of 415 patients underwent hip replacement surgery. We identified 88 cases under the age of 60, between 36 and 60 years (M 36-58, F 37-60), mean age of 50.5 years (M 48.3, F 52.6). Those who met the following inclusion criteria were selected:

- age under 60;
- subjects who did not play risky sports;
- negative history of chronic inflammatory/autoimmune diseases;
- negative history of major trauma;
- exclusion of concomitant pathologies (congenital hip dysplasia, osteochondrosis, osteonecrosis).

Result

Of the 88 cases identified, 37 patients were excluded because they did not meet the inclusion criteria. The causes were 20 osteonecrosis, 9 dysplasias, 3 RA and 5 fracture necrosis, respectively. We therefore evaluated the presence of parameters indicative of FAI in the 51 eligible patients on standard radiographs (AP and Dunn's projection at 45°). Of these patients, 12 had no radiographic sign of FAI while 37, of which 7 bilateral, gave a positive result.
In particular, all patients with signs of FAI had an alpha angle greater than 57° with a mean of 75.7° for males (58°-96.7°) and 76.5° for females (57.8°-88.3°). The HNO values were on average 9.9 for males (7-15.3) and 9.89 for females (5.3-13.4). The pelvic tilt value was at the upper limits with an average of 3.1 cm for males and 3.78 cm for females.
In patients who presented acetabular retroversion, 11 had all three characteristic signs (posterior wall, prominent ischial spine, and cross over sign). While evaluated in isolation, the crossover sign was present in 10 males (retroversion index 47%) and 10 females (retroversion index 45%), the posterior wall in 14 males and 9 females, and the ischial spine prominent in 10 males and 16 females.
In patients presenting with global acetabular overcoverage, 3 males and 1 female had protruded coxa, while the Wiberg angle was on average 32.7° in males (23.6-48.9) and 46.2° in females (18.5-63.6). Overall, 72% of patients with FAI had mixed impingement.

Discussion

Radiographic evaluation in patients with frank osteoarthritis allowed to obtain with sufficient accuracy some parameters such as HNO, pelvic tilt, ischial spine, Wiberg's angle, and profuse coxa. However, it was not always possible to precisely identify the crossover, sign, retroversion index, and the posterior wall index due to bone alterations secondary to the arthrosic process which altered its conformation. Furthermore, due to arthritic functional limitations, Dunn's 45° projection was not always

correctly performed, so the cross-table lateral view was used whenever possible, and in some cases where the lateral projection was not available, the pistol grip sign and/or the alpha angle in AP projections was evaluated.

The literature is rich in additional parameters that can be evaluated for diagnosis of FAI, although only those in clinical practice that have been directly correlated to the disease in question have been selected. Femoral retrotorsion, coxa vara (cervical diaphyseal angle), and other parameters for the pincer type (center-edge CE angle, impingement angle, triangular index, acetabular index) were therefore not taken into consideration for the CAM type deformity (extrusion index, sharp angle, etc.).

Furthermore, another important parameter was not considered as it was a retrospective study: the clinical symptoms before the final evolutionary picture which, in order to diagnose this pathology, are closely associated with the imaging picture [3]: in particular, the characteristic C-sign [26] or insidious inguinal pain that progresses from moderate to marked, limiting its activities and the numerous specific tests that reproduce the impingement (Faber, Fadir, posterior impingement test, etc.). In addition, damage to the femoral cartilage, as measured on T1 and T2 sequences in MRI, appears to have a higher correlation with clinical symptoms than cartilage damage to the acetabulum in patients with symptomatic FAI [27].

Conclusions

The diagnosis of FAI in symptomatic young adults, in the light of the analysis of radiographic data, is likely to be underestimated. However, surgical treatment of FAI is limited in older patients with arthritic degenerative changes and long duration of painful symptoms [28]. In cases of worsening preoperative pain and a low score on functional tests (HHS and WOMAC), the results are poor, and prosthetic treatment is more appropriate. Early diagnosis and treatment therefore play a non-secondary role.

Acknowledgements

None.

Conflict of interest statement

The Authors declare no conflict of interest.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' contributions

All the Authors contributed equally to this work. AB: conceptualization; ML, SF, GG, VDT: data curation; AB, RP: writing-original draft preparation; AB, RP: writing-review and editing; FPL: supervision. All Authors have read and agreed to the published version of the manuscript

Ethical consideration

No experimental procedures have been conducted. All procedures performed in the study involving human participants were in accordance with the ethical standards of the institutional and/ or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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