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Review

The Painful Hip in Young Adults Between Impingement and Mild Dysplasia: Clinical and Instrumental Diagnostical Criteria

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Summary Femoroacetabular impingement and developmental dysplasia of the hip are among the main causes of hip arthritis. In absence of degenerative alterations of the hip, there is the chance of a surgical conservative treatment. This study aims to show the clinical and imaging criteria to a correct and prompt diagnosis. (www.actabiomedica.it)

Key words: Impingement, Dysplasia, Hip arthritis.

It is well known that alterations in the shape of the hip joint lead to an early hip osteoarthritis (1,2,3). This trend is amplified by the contemporary lifestyle, which often implies an intense sport activity: indeed, strong physical training may accelerate those degenerative processes (4,5). The existence of surgical procedures which may correct the deformities of the hip joint, and thus prevent its degeneration in osteoarthritis, makes it crucial to identify this condition in its early phase. This paper aims to offer the most relevant instruments to evaluate the painful hip in the young adult, and identify the possible presence of joint deformities, both in case they were responsible of femoroacetabular impingement (FAI), or of developmental dysplasia of the hip (DDH), before they show evidence of arthritis. The systematic list of all radiographic signs is out of the scope of this paper.

FAI and Dysplasia

The two main causes of early hip osteoarthritis are FAI, and hip dysplasia. Hip dysplasia is characterized by an ill-oriented acetabular articular surface, with loss of coverage (anterior or global) of femoral head. The consequently reduced contact area leads to an excessive and eccentric acetabular load, with the development of early degenerative chondral alterations (6,7).

Dysplasia, which is a long renown disease, is often treated in childhood, and so its incidence has been drastically reduced nowadays. Yet it remains crucial to identify the cases of mild dysplasia, which may still be found in our population.

Femoroacetabular impingement is characterized by an early and pathologic contact during hip joint motion between skeletal prominence of the acetabulum and the femur. It is indeed a dynamic pathological mechanism, which comes from a limitation of the range of movements. Depending on the morphological alteration, we may distinguish two kinds of impingement. The first is the so-called Pincer type, where there is an abnormal acetabular morphology with a focal or general overcoverage of the femoral head; in this type of impingement, the initial damage is labral and involves the circumferential cartilage, while afterwards, due to the posterior subluxation, the chondral damage affects the posterior part of the acetabulum and of the femoral head. The second type of impingement is called Cam, and it is due to a lack of sphericity in the femoral head-neck junction, with decreased head-neck offset. The contact of the aspherical head-neck junction with the acetabulum leads to an abrasion of

the acetabular cartilage or its avulsion from the subcondral bone, a process which is usually localized in the anterosuperior portion of the acetabulum (8,9,10).

The two kinds of impingement, Pincer and Cam, are combined in most patients (more than 80%): it is called 'Mixed Pincer and Cam impingement'. Impingement can be consequence also of an early extraarticular bone pathological contact.

The modern surgical treatment of DDH was described by Ganz (11): the technique is performed through a modified Smith-Petersen approach, and four periacetabular osteotomies and a controlled fracture are performed, in order to completely mobilize the acetabulum from the innominate bone. These osteotomies allow a substantial acetabular reorientation, with three rotational degrees of freedom. The posterior column of the true pelvis remains intact, maintaining stability through an intact continuity of the pelvic ring, and allowing for minimal internal fixation of the fragment.

The surgical treatment of femoroacetabular impingement was first described by Ganz (12). He suggests an approach using a trochanteric flip: the hip is exposed anteriorly and dislocated in the same direction; respecting the integrity of the external rotator muscle and giving full protection to the vascular supply of the femoral head. This procedure offers the best view of the hip joint. Subsequently, other approaches have been used: the Hueter direct anterior approach, and the arthroscopic approach.

In any way, the surgical treatment in cam impingement lies mainly in removing any nonspherical portion of the head, improving the neck offset and subsequent clearance (femoral neck osteoplasty).

For pincer impingement, this includes reducing the anterior over coverage by excising the bony prominence at the rim or in some case of severe acetabular retroversion a reorientation with a reverse periacetabular osteotomy.

In the contact region between femur and acetabulum, the torn or degenerate area of the labrum is also excised, and the remainder of the labrum is reattached to the rim using suture anchors.

Many other disorders of hip joint can superficially mimic impingement and dysplasia but they do not depend on articular deformity. Among these, we can list rheumatological diseases, osteonecrosis of femoral head, transient hip osteoporosis, stress fractures, infiltrative bone disease, articular hyperlaxity.

Clinical presentation

The patients are young and active, usually in their 20s-40s, and suffer from painful hip. Pain may be differently localized: it may be felt like a knife sharp pain in the groin, or sometimes a pain irradiates to trochanteric or anterior thigh region, pelvic posterior region, gluteus and sacroiliac. Occasionally, it arises after an acute traumatic episode; yet it often occurs insidiously and tends to worsen with time (13). High sport and heavy work activity are surely a relevant cofactor to consider in the clinical history, but they do not represent essential conditions to this pathology. Indeed, it sometimes arises in sedentary patients. Generally, the pain does not relieve spontaneously. In the impingement, at a first stage, the symptoms are felt after or during physical activity, or in case of activities with an extreme range of movements; later, they occur also during a longtime sitting position. The hip with biomechanical abnormalities may also produce limp, a sensation of instability and weakness, articular clicks or sensations of locking in the hip. In impingement cases it is often present a hip with limited range of motions due to articular morphology. For example, most sportive patients have never been able to make a correct split, and they have always been limited in stretching. On the other side, patients affected by impingement involved in high range of movement demanding activities (free climbers, dancers, martial artists, etc.) may show a normal or increased articular mobility, especially if impingement is associated with hyperlaxity.

Patients live together with their deformities since childhood and they are used to them; for this reason, they do not often refer spontaneously many important symptoms, and it is necessary to ask them directly.

In clinical examinations, it is relevant to use specific tests (14,15)

Impingement test: the hip is positioned in 90° of flexion ad forced in internal rotation and adduction, then the hip is tested in many degrees of flexion. A

positive test (pain) is present for anterior femoroacetabular impingement, but sometimes is present also in dysplastic hip, in relation with degenerative labrum tear.

Posterior impingement test: the patient is in supine position with the hip positioned in maximal extension; the test is positive when there is painful forced external rotation, and it is related with chondral damage in the posterior area of acetabulum in patients affected by impingement.

Apprehension test: the patient is in supine position with the hip positioned in extension; the test is positive when there is instability sensation in external rotation. The test is positive in dysplastic hip with reduced anterior acetabular coverage.

Radiographic evaluation

Standard conventional radiographic imaging in evaluating the alterations in the shape of the hip joint is not only a primary role, but also cost-effective and of rapid execution.

It represents the first step after clinical examination, while MR and MR arthrography are second stage exams, as they are useful for a more accurate morphological definition of the deformity, or for an evaluation of the degenerative state.

Standard radiographic technique includes two radiographs: an anteroposterior pelvic view and an axial cross-table view of the proximal femur. In this exam, a correct positioning of the patient and an accurate radiographic technique are crucial for an accurate result.

For the anteroposterior pelvic view the patient is in supine position with the legs 15° internally rotated; the film-focus distance is 1.2 m., and the central beam is directed to the midpoint between a line connecting anterosuperior iliac spines and the superior border of the symphysis (16,17,18).

The axial cross-table view of the proximal femur is obtained by placing the leg internally rotated, with a film focus distance of 1.2 m., and with the central beam directed to the inguinal fold. An alternative to the axial view is a Dunn view, in 45° of flexion.

Moreover, a faux profile of Lequesne may be used for quantification of anterior coverage; this exam is more useful for dysplasia than for FAI; sometimes, it may be of use a lateral view of the pelvis, to determine the individual pelvic tilt: it is an angle formed by an horizontal line and a line connecting upper border of symphysis and the sacral promontory. A neutral tilt is a pelvic inclination angle of 60°.

Radiographic reference values of acetabulum (19)

Position, orientation and width of acetabular surface are relevant for a healthy hip. Undercoverage (developmental dysplasia of the hip [DDH]) and overcoverage (such as "pincer"-type femoroacetabular impingement) are two opposite kinds of acetabular pathological morphology. Both of them can lead to degenerative hip changes, until arthritis.

Pathomechanism differs in each of these conditions: static overload in undercoverage may cause higher joint contact pressures and subsequent degeneration of the articular cartilage, while dynamic conflict in overcoverage may lead to early pathological contact between the acetabulum and the femoral head-neck junction, that may cause chondrolabral damage.

The radiographical parameters listed below are considered in the study of acetabular anatomy; all these parameters, except the crossover sign, differ among overcoverage and undercoverage; among them, lateral center-edge angle (LCE), anterior and posterior coverage increase steadily from dysplasia, through physiological condition, to overcoverage and severe overcoverage. In contrast, extrusion and acetabular index, Sharp angle decrease from dysplasia to severe overcoverage.

Lateral center-edge angle (LCE): the angle formed by a line parallel to the longitudinal pelvic axis and a line connecting the center of the femoral head with the lateral edge of the acetabular sourcil (figure 1).

Dysplasia < 22°, normal 23°-33°, overcoverage (FAI) 34°-39°, severe overcoverage < 40°.

Acetabular index: angle formed by a horizontal line and a line through the most medial point of the sclerotic zone of the acetabular roof and the lateral edge of the acetabulum (figure 2).

Dysplasia < 14°, normal 3°-13°, overcoverage (FAI) -7°to 2°, severe overcoverage < -8°.

Extrusion index: percentage of uncovered femoral head in comparison to the horizontal head diameter.

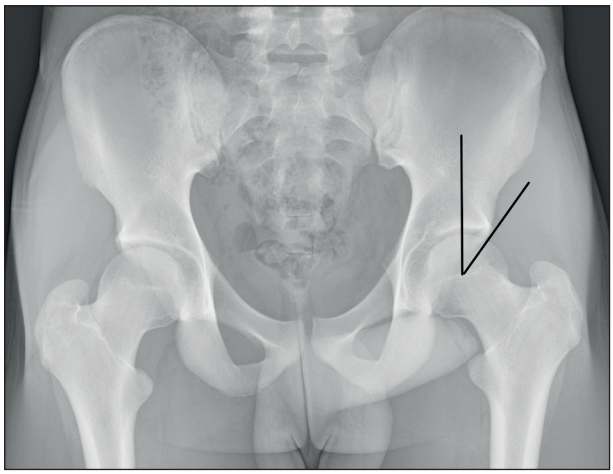

Figure 1. Lateral center-edge angle (LCE): the angle formed by a line parallel to the longitudinal pelvic axis and a line connecting the center of the femoral head with the lateral edge of the acetabular sourcil.

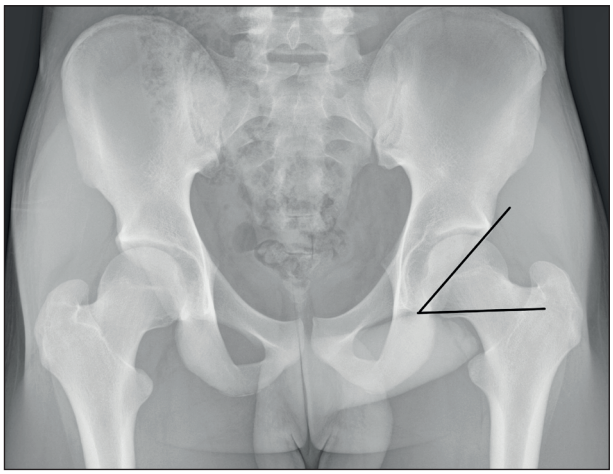

Figure 3. Sharp angle: angle formed by horizontal line and a line through the caudal tip of the teardrop and the lateral edge of the acetabulum.

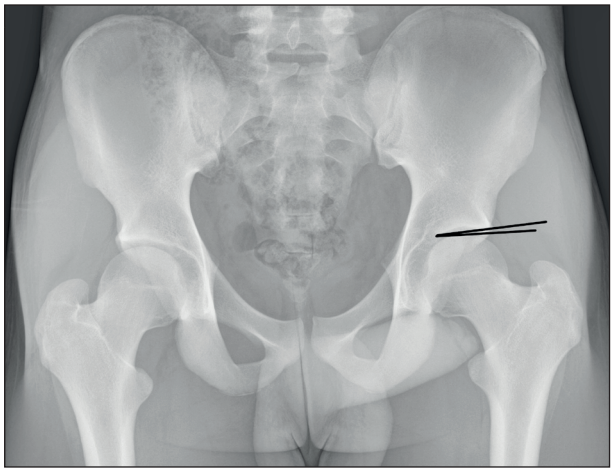

Figure 2. Acetabular index: angle formed by a horizontal line and a line through the most medial point of the sclerotic zone of the acetabular roof and the lateral edge of the acetabulum.

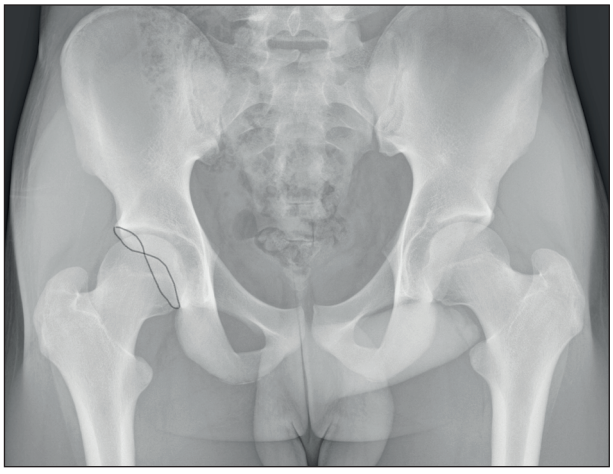

Figure 4. Crossover sign: positive if the projected anterior wall crosses the posterior wall.

Dysplasia > 27, normal 17-27, overcoverage (FAI) 12-16, severe overcoverage < 11.

Sharp angle: angle formed by horizontal line and a line through the caudal tip of the teardrop and the lateral edge of the acetabulum (figure 3).

Dysplasia < 43°, normal 38°-42°, overcoverage (FAI) 34°- 37°, severe overcoverage < 34°.

Crossover sign: positive if the projected anterior wall crosses the posterior wall (figure 4).

Dysplasia < 14°, normal 3°-13°, overcoverage (FAI) -7°to 2°, severe overcoverage < -8°

Posterior coverage: the percentage of femoral head covered by the posterior acetabular rim in posteroanterior direction.

Dysplasia < 35, normal 36-47, overcoverage (FAI) 48-55, severe overcoverage < 56.

Posterior wall sign: positive if the posterior acetabular rim is projected medial to the center of the hip.

Anterior coverage: the percentage of femoral head covered by the anterior acetabular rim in AP direction.

Dysplasia < 14, normal 15-26, overcoverage (FAI) 27-32, severe overcoverage < 33 (Table 1).

Table 1. Radiographic Reference Values for Acetabular Under- and Overcoverage

Parameter	Dysplasia	Control	Overcoverage	Severe overcoverage
LCEA (degrees)	< 22	23–33	34–39	< 40
Acetabular index (degrees)	< 14	3–13	–7 to 2	< –8
Sharp angle (degrees)	< 43	38–42	34–37	< 34
Posterior wall sign (percent positive)	Positive	Positive	Positive or negative	Negative
Anterior coverage (percent)	< 14	15–26	27–32	< 33
Posterior coverage (percent)	< 35	36–47	48–55	< 56
Extrusion index (percent)	> 27	17-27	12-16	< 11

Coxa profunda: the floor of the fossa acetabuli touching or overlapping the ileoischial line medially (figure 5).

Protrusio acetabuli: the femoral head is overlapping the ileoischial line medially.

Prominence of ischial spine: in clinical practice, when a cross over sign is seen, the ischial spine also is seen as a prominence in the pelvic cavity. There is a high correlation between the cross over sign and the prominence of ischial spine, that is easily visible on the AP radiograph as a projection in the pelvic cavity and is not easily confused, making it a reliable radiographic landmark for retroversion (20).

Radiographic reference values of proximal femur (17)

In Cam impingement, there is an aspherical part of femoral head. This osseous bump develops on the head-neck junction, and it leads to a decrease of head-neck offset.

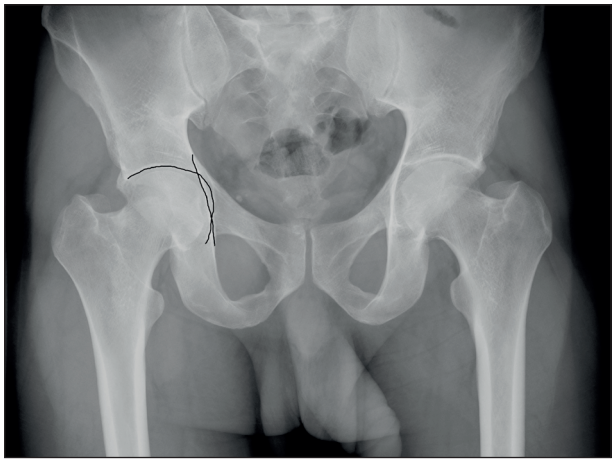

Figure 5. Coxa profunda: the floor of the fossa acetabuli touching or overlapping the ileoischial line medially.

Pistol-grip deformity: flattening on radiographs of the usually concave surface of the lateral aspect of the femoral head due to an abnormal extension of femoral epiphysis (figure 6).

Angle α: the angle between the femoral neck axis and a line connecting the head center with the point of beginning asphericity of head-neck contour (figure 7). It is useful to quantifies the amount of asphericity of

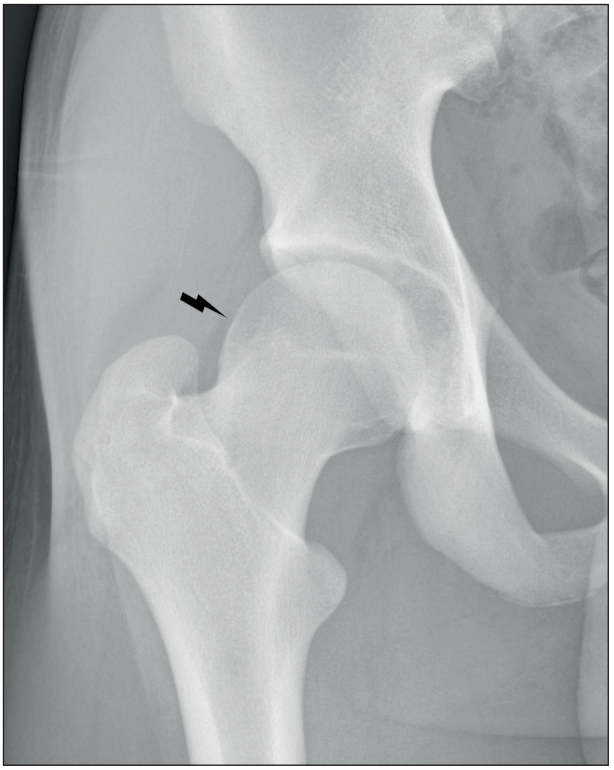

Figure 6. Pistol-grip deformity: flattening on radiographs of the usually concave surface of the lateral aspect of the femoral head due to an abnormal extension of femoral epiphysis.

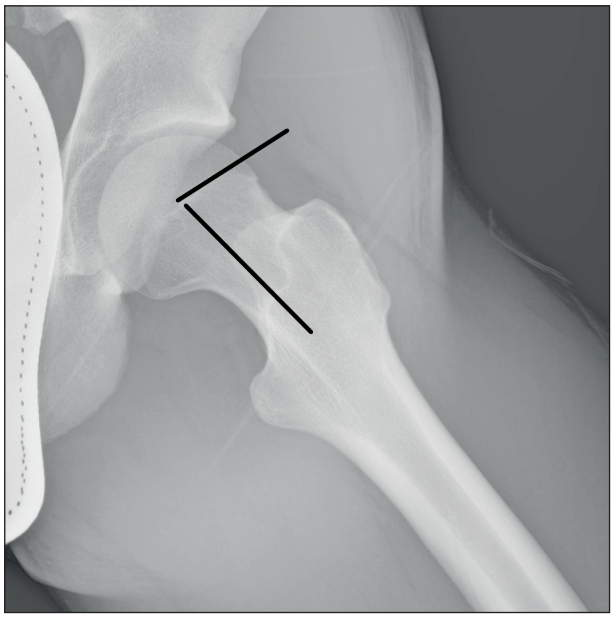

Figure 7. Angle α: the angle between the femoral neck axis and a line connecting the head center with the point of beginning asphericity of head-neck contour.

femoral head. An angle exceeding 50° is an indicator of an abnormal shape.

Anterior offset: the difference in radius between the anterior femoral head and the anterior femoral neck on a radiographic axial view.

Normal 11.6 +/- 0.7 mm, FAI 7.2 +/- 0.7 mm

Offset ratio: the ratio between the anterior offset and diameter of the head.

Normal 0.21 +/- 0.03, FAI 0.13 +/- 0.05

Coxa vara: centrum collum diaphyseal angle less than 125°, has been recognized as a cause of a cam or an extraarticular impingement.

Shenton line: is an imaginary curved line drawn along the inferior border of the superior pubic ramus (superior border of the obturator foramen) and along the inferomedial border of the femoral neck. This line should be continuous and smooth. Interruption of the Shenton line can indicate developmental dysplasia of the hip.

Secondary radiographic changes of the Hip

Untreated hip dysplasia or impingement leads to degenerative changes of the hip, reactive ossification, sclerosis of subchondral bone, cysts, osteophytes, narrowing of the joint space.

The Tönnis classification of osteoarthritis is not at issue here: it is just mentioned to say that if degenerative alterations of the joint are that evident, then the surgical treatment is not resolutive (21).

At any rate, secondary hip changes are radiographically evident also in early stages of the pathology:

Ossification of labral basis and osseous apposition of acetabular rim, related to recurrent impingement (figure 8).

Stress fracture of the acetabular rim, with separation of a prominent bone fragment from adjacent bone margin (os acetabuli), because of abnormal stress in impinging hips (figure 9).

Double contour of acetabular rim, for additional reactive bone apposition at the osseous rim of acetabulum, still related with impingement (22).

Linear indentation: reactive cortical thickening in anterior portion of femoral neck, in axial view, depending on early and pathologic contact during hip joint motion between skeletal prominence of the acetabulum and the femoral neck (figure 10-11).

Herniation pit: radiolucency area surrounded by sclerotic margin, typically located in the anterior

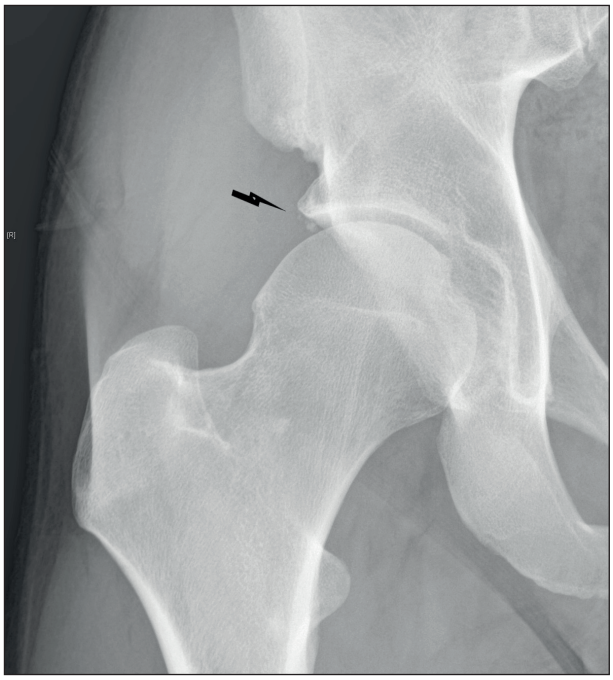

Figure 8. Ossification of labral basis and osseous apposition of acetabular rim.

Figure 9. Stress fracture of the acetabular rim, with separation of a prominent bone fragment from adjacent bone margin (os acetabuli).

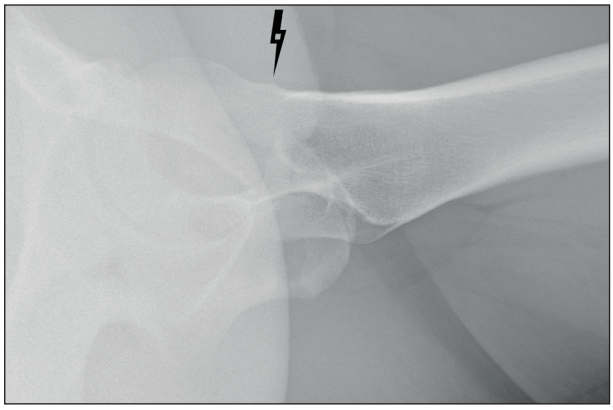

Figure 10. Linear indentation: reactive cortical thickening in anterior portion of femoral neck, in axial view, depending on early and pathologic contact during hip joint motion.

proximal superior quadrant of femoral neck (figure 12-13) (23,24). It occurs in impingement, but herniation pits are not always associated with symptomatic impingement.

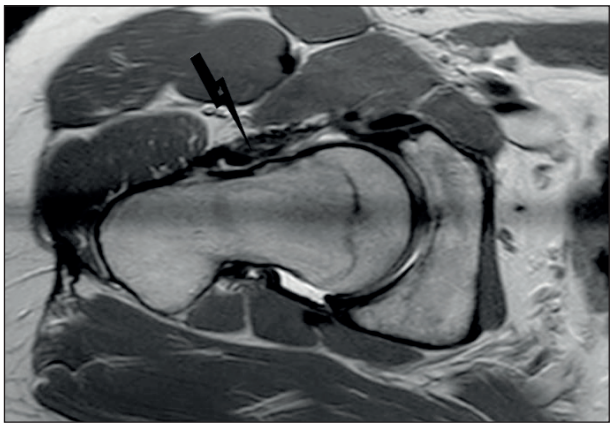

Figure 11. Linear indentation: reactive cortical thickening in anterior portion of femoral neck (MR arthrography view). It is also appreciable cartilage damage in the posterior joint.

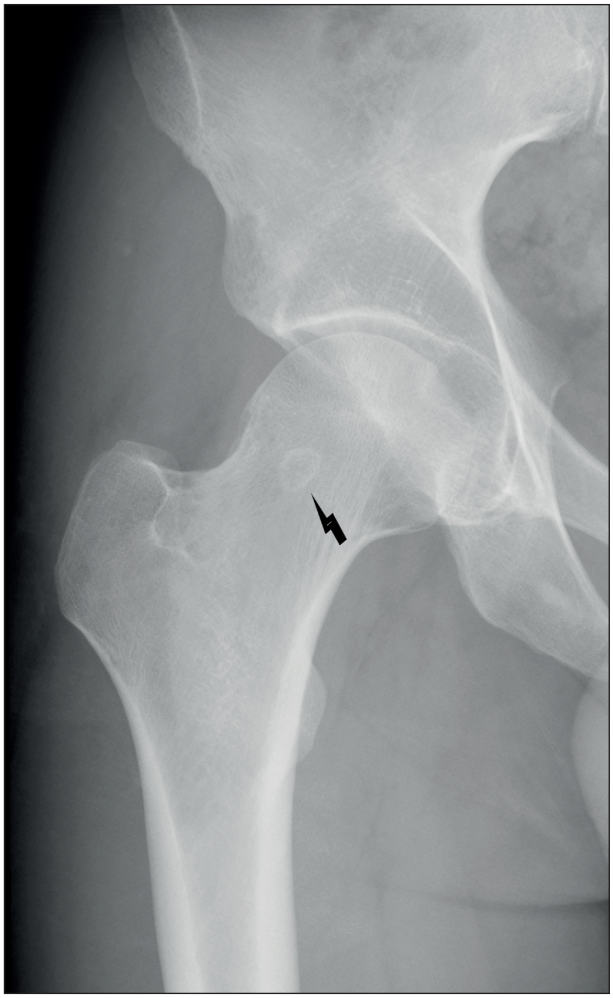

Figure 12. Herniation pit: radiolucency area surrounded by sclerotic margin.

Ultrasound

Ecography is a valuable tool to answer specific questions regarding soft tissues hip pathology.

It is useful to asses bursae, tendons or joint effusion. Moreover, it is helpful as a guide for diagnostic or therapeutic interventional procedures such as aspiration of synovial fluid, or injection of steroids or anesthetics.

Nevertheless, it is not useful to the diagnosis of impingement or developemental dysplasia of the hip in adult.

Computed tomography

The high spatial resolution of CT provides an excellent representation of cortical and trabecular bone and joint bone anatomy, but it is not of routine use in these pathologies.

It may be useful in studying femoral retroversion, which may occur as a primary entity or be posttraumatical, and can be related with femoroacetabular impingement.

Magnetic Resonance

The role of MR is early detection of many hip pathologies, and exclusion of osteonecrosis, transient hip osteoporosis, stress fractures, infiltrative bone disease, septic arthritis, osteomyelitis if are suspected.

Anyway, RM arthrography has a better spatial resolution in defining intraarticular degenerative changes.

RM arthrography

After clinical examination and conventional radiographic imaging, the second level investigation is RM arthrography that better evaluates the hip for abnormality associated with impingement and dysplasia, but also can be used to confirm or exclude labral tears, cartilage damage or other signs of joint degeneration.

RM arthrography protocol has been developed by Locher and coll. and provides to obtain over the standard sagittal, axial and coronal images, also radial images obtained through the axis of femoral neck.

In this kind of patients, the evaluation of the degree and localization of chondral and labral damage is of primary importance in planning a surgery. In cases of lesion or detachment of the labrum, or chondral lesions, the infiltration of contrast medium is evident (figures 13-14) (25,26).

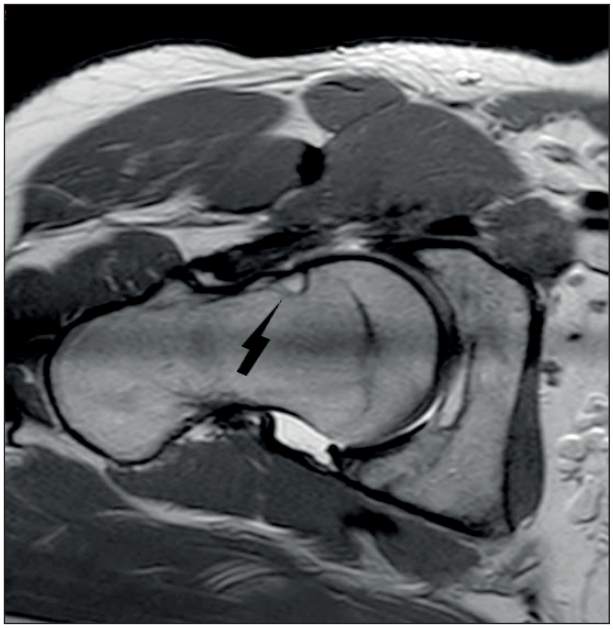

Figure 13. Herniation pit (MR arthrography view).

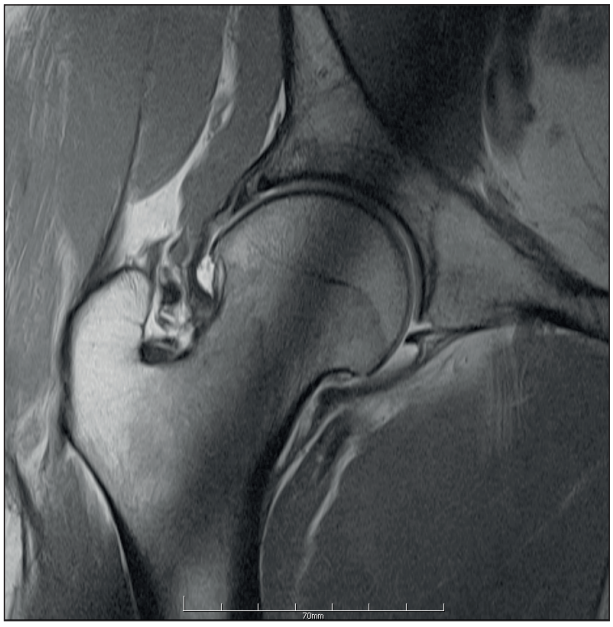

Figure 14. MR arthrography, chondral and labral damage.

Quite wide, even if not at full thickness, abrasions of cartilage lead to a migration of femoral head inside the chondral defect. This may be observed in RM arthrography, with an asymmetry of joint spaces characterized by a reduction of joint space in correspondence of the chondral defect (generally anterior, or anterosuperior), and by the infiltration of contrast medium in the opposite joint space (generally posterior).

The migration of the femoral head is evidence of advanced pathology; in this case surgery is contraindicated.

Discussion

The onset of hip disorders related with DDH and FAI is often slow and insidious. The habit to small limitations makes it sort of a second nature, but later, with the beginning of degenerative changes, pain leads the patient to the doctor.

The insidious nature of the pain makes important to distinguish its source, whether it raises from the hip or from another district. Symptoms may be irradiated from the back, or be related to periarticular disorders such as bursitis, tendinitis, muscular disbalance, or also depend on non orthopedic origin like inguinal hernia. Moreover, pain often irradiates from the hip to the knee, gluteus and sacroiliac. A good way to identify disorders of hip joint is impingement test: it has a high sensibility and specificity in pain from the hip, but it is less specific in discerning the different pathologies of the hip. In a second moment, specific radiographic parameters can be used to confirm the diagnosis of this entity with timely delivery of treatment.

The described reference values are used to support the choice of the most appropriate surgical option for symptomatic hips. This can be very helpful in mild DDH, in borderline cases of mixed DDH and pincer pathomorphologies, or in the evaluation of acetabular coverage.

We emphasize that these reference values apply only to symptomatic patients. Diagnosis and treatment in these patients must be used in addition to patient history, clinical findings, and hip morphology. Sometimes, patients with typical radiographic features of femoroacetabular impingement or mild hip dysplasia may be asymptomatic. In these situations, the recourse to surgical treatment is under discussion for asymptomatic dysplastic hips, while this option is not taken into account for impingements.

Recognition of FAI and DDH in their first stages, i.e. before the degenerative process is advanced, and its early treatment, is likely to have a considerable impact on the natural history of the disease, delaying the onset of end-stage arthritis in these young patients.

Surgical treatments of femoroacetabular impingement and hip dysplasia focus on correcting the deformities of the hip joint, in the former case improving the clearance of hip motion and alleviating of femoral abutment against acetabular rim, in the latter reorienting acetabular version. The results of these treatments are good. After correction of impingement, Steppaker and coll. have found decreased pain and improved function in a vast majority of patients with a survival rate of surgery of 80% at 10-year follow up (27,28), and cumulative survivorship of the hip at 20-years was 60%, and at 30-years was 32% after periacetabular osteotomy in dysplastic hips (29,30). An important predictive factor for good results is a non-arthritic joint.

To avoid the degeneration in osteoarthritis, it is critical to identify these conditions in their early phase, in order to intervene with a surgical treatment.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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