Strategy and optimization of diagnostic imaging in painful hip in adults

A. Blum *, A. Raymond , P. Teixeira
Service d’imagerie Guilloz, CHU de Nancy, 54000 Nancy, France

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A B S T R A C T

Diagnostic imaging strategy in painful hip depends on many factors, but in all cases, plain X-ray is the first investigation. It may be sufficient to reach diagnosis and determine treatment options. More effective but more expensive exploration is indicated in two circumstances: when plain X-ray is non-contributive, and when diagnosis has been established but more accurate imaging examination is needed to guide treatment. Following radiography, the choice of imaging techniques depends not only on the suspected pathology but also on the availability of equipment and its performance. MRI is probably the technique that provides the most comprehensive results; recent improved accessibility has significantly simplified the diagnostic algorithm. CT remains invaluable, and current techniques have reduced patient irradiation to a level similar to that of standard X-ray. Finally, cost is an important consideration in choosing the means of exploration, but the overall financial impact of the various strategies for diagnosis of painful hip is not well established. This article aims to provide a simple and effective diagnostic strategy for the assessment of painful hip, taking account of the clinical situation, and to detail the most typical semiologic patterns of each disease affecting this joint.

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1. Introduction

Plain X-ray is the first imaging investigation to be performed in case of painful hip. It may be sufficient to establish diagnosis and guide treatment, especially when osteoarthritis (OA) is revealed [1].

More effective but more costly examinations are indicated in two circumstances: when plain X-ray is non-contributive, and when diagnosis has been established but more accurate imaging assessment is needed to guide treatment.

The choice of imaging techniques depends not only on the suspected pathology but also on the availability of equipment and its performance. All of the techniques are operator-dependent, and thus more contributive when the radiologist is specialized in osteoarticular imaging.

Radiologic follow-up is sufficient if exact immediate diagnosis is not indispensable for guiding treatment [1]. MRI provides the fullest analysis, and has become more readily accessible. CT is irreplaceable, and current techniques make it scarcely more irradiating than plain X-ray. Cost is a critical criterion of choice, but the financial implications of the various diagnostic strategies in painful hip are not well established.

The present article focuses exclusively on non-traumatic, non-prosthetic painful hip.

2. Radiographic step

The type of X-ray depends on what pathology is suspected: joint, bone abarticular, or remote involvement (Table 1). In practice, radiologic assessment should comprise AP pelvic, AP hip and comparative false-profile views. These are the so-called coxometric views, analyzing hip-joint architecture and screening for and quantifying dysplasia. In case of suspected femoroacetabular impingement (FAI) or early OA without dysplasia, assessment also includes Dunn’s lateral femoral neck view (cf. below).

3. Other explorations

When radiologic assessment proves insufficient, other examinations may be prescribed. Their effectiveness depends on the structures to be examined (Table 2), equipment quality, operator experience and the relevance of the question to be explored. This last point is often overlooked, but is crucial (Fig. 1). Cost has to be taken into account, although there has been no assessment of the overall cost of the various diagnostic strategies (Table 3).
Table 1
X-ray views for non-traumatic painful hip.

<table>
<thead>
<tr>
<th>View</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP pelvic</td>
<td>Global analysis</td>
</tr>
<tr>
<td></td>
<td>Joint-line</td>
</tr>
<tr>
<td></td>
<td>Head sphericity</td>
</tr>
<tr>
<td></td>
<td>Joint dysmorphism</td>
</tr>
<tr>
<td>AP hip (ascending)</td>
<td>Anterior femoral head</td>
</tr>
<tr>
<td>Lequesne’s “false profile”</td>
<td>Anterosuperior and posterior joint-line</td>
</tr>
<tr>
<td>“Profil médical de Cochin”*</td>
<td>Anterior acetabular cover</td>
</tr>
<tr>
<td>or urethral lateral view</td>
<td>Femoral head contours</td>
</tr>
<tr>
<td>Dunn lateral view</td>
<td>Cervicoephalic junction morphology</td>
</tr>
</tbody>
</table>

* Combination of an internal Judet oblique view and a 45° Dunn view.

Table 2
Examination value according to target structure.

<table>
<thead>
<tr>
<th>Technique</th>
<th>Cartilage</th>
<th>Labrum</th>
<th>Effusion/ synovitis</th>
<th>Bone</th>
<th>Abarticular soft-tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain X-ray</td>
<td>++</td>
<td>0</td>
<td>0</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>Ultrasound</td>
<td>0</td>
<td>0</td>
<td>++</td>
<td>0</td>
<td>+++</td>
</tr>
<tr>
<td>CT</td>
<td>++</td>
<td>0</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>CT arthrography</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>MRI</td>
<td>++</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>MR arthrography</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Bone scan</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>SPECT-CT</td>
<td>+*</td>
<td>0</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
</tbody>
</table>

SPECT: single photon emission computed tomography.

Table 3
Hip exploration imaging costs in France.

<table>
<thead>
<tr>
<th>Technique</th>
<th>Cost to nearest euro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain X-ray</td>
<td>33</td>
</tr>
<tr>
<td>Ultrasound</td>
<td>38</td>
</tr>
<tr>
<td>CT</td>
<td>125*</td>
</tr>
<tr>
<td>CT arthrography</td>
<td>193*</td>
</tr>
<tr>
<td>MRI on general scanner</td>
<td>252*</td>
</tr>
<tr>
<td>MRI on dedicated scanner</td>
<td>183*</td>
</tr>
<tr>
<td>MR arthrography on general scanner</td>
<td>321*</td>
</tr>
<tr>
<td>MR arthrography on dedicated scanner</td>
<td>252*</td>
</tr>
<tr>
<td>Bone scan and SPECT-CT</td>
<td>180 (late phase)</td>
</tr>
<tr>
<td></td>
<td>268 (several phases)</td>
</tr>
<tr>
<td></td>
<td>360 (+ SPECT)</td>
</tr>
</tbody>
</table>

SPECT: single photon emission computed tomography.

* Cost in the French system depends on the “technical set price” (forfait technique). The most usual set prices are used here.

3.1. Ultrasound

Ultrasound is very useful for exploring abarticular structures, but less so for the hip-joint itself. It requires top-quality equipment and a high-frequency probe for the superficial tendons, powerful Doppler and an experienced operator.

It is radiation-free, inexpensive, without danger and readily accessible, shedding light on the status of the tendons and adjacent structures and soft-tissue. It allows dynamic study, to reveal impingement or tendon instability and can also shed light on peri-articular structures and guide injection (Fig. 2).

3.2. CT and pelvic CT arthrography

CT and pelvic CT arthrography are very useful for studying cortical and cancellous bone and analyzing calculations; CT arthrography also assesses the joint compartment (cartilage, labrum, foreign bodies) [2,3].

3.2.1. Measurements

CT and pelvic CT arthrography allow measurements to be taken; these should be bilateral comparative. Femoral neck anteverision, acetabular version and α angle can be measured.

Classically, acetabular version is the angle subtended by the tangent to the anterior and posterior edges of the acetabulum and the tangent to the ischial spine on a slice through the center of the femoral heads, in which case normal anteverision is 22.5 ± 3° [4]. According to Lazennec et al., functional anteverision should be measured, taking account of the sagittal orientation of the pelvis; this is determined by the sacral slope, measured on lateral standing and seated views, on an oblique axial slice defined by the sacral slope in standing or seated position [5].

In FAL, acetabular retroversion inducing impingement is explored for in the proximal third of the joint (Fig. 3). The α angle is best measured on a double oblique slice through the anterosuperior quadrant of the acetabulum (Fig. 4), and is normal when less than 55°.

3.2.2. Intra-articular injection

Despite its much higher contrast resolution than plain X-ray, CT is unable to analyze the elements of the joint whereas CT arthrography includes the necessary intra-articular iodized contrast medium injection [2,6,7]. A corticosteroid can be injected in the same step, for diagnostic or therapeutic purposes [2,8]. The unrivalled spatial resolution of CT arthrography makes it no doubt the optimal means of analyzing the cartilage [3,9,10] (Fig. 5). It also shows great precision, approximating 90%, in diagnosing labral tear [11,12].

3.2.3. Dosimetry

CT-related irradiation has been reduced by some 50% in recent years [13,14]. Even so, indications need carefully weighing, especially in young subjects.

3.3. MRI and MR arthrography

MRI can be highly effective, but depends on many factors: equipment quality, exploration protocol, sequence choice, and patient morphotype. Results are thus variable. Moreover, it is not always well suited for analyzing calcified tissue and thus cannot be interpreted independently of plain X-ray or CT.

3.3.1. MRI or MR arthrography

Despite the increasing power of MRI, controversy remains as to the interest of intra-articular injection to improve contrast. Two meta-analyses showed great variation in sensitivity and specificity in diagnosing labrum and cartilage lesions [10,15].

Fig. 1. Simplified imaging flow-chart in painful hip. Other pathways are possible. FAL: femoroacetabular impingement.
In labrum lesions, 0.5–3T MRI showed sensitivity and specificity of respectively 66% and 79%, compared to 87% and 64% on 0.5–3T MR arthrography, which showed greater diagnostic precision [15]; for cartilage lesions, the figures were 59% and 94% on MRI and 62% and 86% on MR arthrography [10].

A recent study reported overall superiority of MR arthrography over MRI [16]: in labrum tear, sensitivity was 81% and 69% for two readers on MR arthrography, versus only 50% for MRI; specificity was 100%. Inter-observer agreement was better for MR arthrography than MRI. In cartilage lesions, MR arthrography was more effective than MRI in the acetabulum but with no significant difference in the femur.

3.4. Bone scan and SPECT/CT

Bone scan with radioactive technetium 99m-labelled biphosphonates shows excellent sensitivity but lacks specificity (Fig. 6). Hybrid SPECT/CT bone imaging combines SPECT (single photon emission computed tomography) and CT. It shows better location...
Fig. 4. \(\alpha\) angle measured by princeps method (a and b) and by radial reconstruction (follow steps from a to d): a: oblique axial slices are superimposed to a frontal slice through the middle of the neck or a little above, depending on the position of the cervicocephalic bump; b: on this slice, a line is drawn through the femoral neck axis (1), then the circle of the femoral head and finally the line through the center of the circle and the point of separation between the circle and the anterior bone contour (2). The \(\alpha\) angle is subtended by these 2 lines. In the present case, it exceeds 55° due to a bump at the anterior cervicocephalic junction (arrow); c: radial reconstruction is performed from the above femoral neck axis; d: the one through the anterosuperior region (10–11 o'clock) is selected. Note anterosuperior labral tear (arrowhead).

Fig. 5. Osteoarthritis of the right hip in a 31-year-old female: a, b: plain radiographs: minimal superior pole joint impingement; c, d: CT arthrograph: grade 4 cartilage ulceration of the summit of the head and overall cartilage thinning in the posterior head; e, f: MRI with insufficient spatial resolution, overlooking the lesions; g, h: MRI arthrograph with same slice planes and better spatial resolution, showing same abnormalities as CT arthrography. CT arthrography is the best imaging modality for analyzing cartilage ulceration.
and analysis of abnormalities detectable on conventional bone scan, of which it is the natural prolongation.

4. Joint pathology

Diagnostic strategy depends on health status, biological results and plain X-ray, which may suffice for assessment in osteoarthritis. When more precise assessment is required, CT arthrography and MRI are the most usual examinations. MR arthrography as first-line examination is reserved for suspected FAI and hip pain in athletes (Fig. 1).

4.1. Osteoarthritis of the hip

Radiologic assessment is usually able to identify OA signs and any architectural defect. In case of doubt, two strategies are available: MRI to rule out any other cause of pain, and CT arthrography with intra-articular corticosteroid injection to confirm the diagnosis of OA.

CT arthrography identifies signs of OA more precisely than plain X-ray. MRI is less sensitive than CT arthrography in identifying cartilage lesions, but may reveal focal medullary edema, synovitis or joint effusion (Fig. 5).

4.2. Rapidly destructive osteoarthritis (RDO)

RDO is, above all else, characterized by the speed of chondrolysis, whether rapid (at least 2 mm impingement per year) or semi-rapid (1–2 mm/year). Articular chondrocalcinosis (ACC) is implicated in one-third of cases. Chondrolysis is rapidly followed by osteolysis.

Fig. 6. Transient medullary edema syndrome in the right hip in a 49-year-old male: a, b: early and late bone scan showing 3-phase hyperfixation, indicating elevated capillary permeability, hyperemia and osteoblastic hyperactivity.

Fig. 7. Rapidly destructive osteoarthritis of the hip in a 42-year-old female: a–c: plain X-ray and MRI: moderate osteoarthritis of the hip with cartilage ulceration and joint effusion, but almost no osteophytosis; d–f: same assessment less than 1 year later: marked joint-space narrowing and bone destruction associated with medullary edema of the femoral head.
Fig. 8. Cam-effect femoroacetabular impingement in a 36-year-old male: a, b: CT arthrography in anatomic position, frontal and sagittal slices: labral tear (black arrow) and some cartilage ulceration of the anterior roof (arrowheads); c, d: frontal slices in painful position (flexion + internal rotation of the thigh) in the same patient, showing cervicocephalic bump positioned adjacent to labrum. Note also small cyst (white arrow).

Fig. 9. Morphologic modifications or findings on pelvic view possibly associated with femoroacetabular impingement by pincer-effect (drawings by R. Sutter [24], modified). The first 2 are associated with excess global cover and the last 3 with acetabular retroversion: a: coxa profunda: the back of the acetabulum (red) and the ilioschial line are superimposed; b: acetabular protrusion: the back (red) lies more than 5 mm inside of the ilioschial line; c: crossing sign: due to superior acetabular retroversion and inferior anteversion, the lines of the anterior (red line) and posterior acetabular edges cross; d: posterior wall sign: the center of the femoral head projects beyond the posterior wall (red line); e: ischial spine sign: the ischial spines project into the pelvic cavity.

Fig. 10. Pincer-effect femoroacetabular impingement in a 27-year-old female: a: imperfect pelvic view nevertheless showing near-zero acetabular version on right and left and medial protrusion of the ischial spines (arrows); b: CT: long ischial spines (arrows) and near-zero acetabular version on right and left; c: sagittal slice: distinct thinning of anterior cartilage (arrow).
MRI systematically detects joint effusion and intense medullary edema of the femoral head and neck; associated cysts and subchondral lesions are frequent [17] (Fig. 7).

4.3. Femoroacetabular impingement

FAI consists in abnormal, painful contact between the proximal femur and the anterosuperior edge of the acetabulum during repeated flexion exceeding 90° combined to internal rotation. It is observed in young adult athletes. It may cause labrum and juxtalabral cartilage lesions, contributing to early OA.

It is associated with morphologic abnormalities of the acetabulum or cervicocephalic junction or, more often, both:

• hypertrophy of the cervicocephalic junction, which comes into contact with the anterior edge of the acetabulum (cam-effect);
• anterior acetabular wall projection (pincer-effect); the same effect may be induced by pelvic hyperflexion.

These abnormalities may also be asymptomatic.

In cam-effect FAI, the cervicocephalic junction hypertrophy may be anterior, lateral or global. The morphologic abnormality is discernible on plain X-ray. When lateral, it can be detected on AP view: the femoral head shows “pistol-grip”. When anterior, it can be detected on a Dunn lateral view.

As well as the above morphologic abnormalities, CT or MR arthrography can also detect:

• cartilage involvement limited to the anterosuperior acetabulum;
• labrum tear, or acetabuli and/or cyst on the anterior side of the femoral neck (“herniation pit”) (Fig. 8).

In pincer-effect FAI, anterior acetabular wall projection may be global (coxa profunda or acetabular protrusion) or limited to the superior third of the joint. It is usually detected on plain X-ray (Figs. 9 and 10).

CT or MR arthrography can measure acetabular retroversion in the superior part of the joint, revealing:

• degenerative disease of the anterosuperior labrum (hypertrophy, fissure, cyst, ossification);
• variable and later cartilage involvement: postero-inferior (“contre-coup” lesion) or anterosuperior cartilage abrasion, neighboring the labral lesion.
Fig. 13. Septic osteoarthritis of the left hip in a 25-year-old male, with an unidentified origin: a: initial X-ray: analgesic position without other abnormality; b, c: CT scan at D20 with IV contrast medium injection: disappearance of subchondral plate of the femoral head and acetabulum, subchondral erosion (arrow) and joint effusion; d: X-ray at 2 months: considerable joint deterioration.

Fig. 14. Villonodular synovitis in a 43-year-old female: a: plain X-ray is normal; b: CT arthrography: distension and severe synovial proliferation of joint; c, d: T2 and T2*-weighted sequences: severe synovial proliferation with fall in T2*-weighted signal, indicating hemosiderin and villonodular synovitis.
4.4. Inflammatory coxitis

In incipient rheumatoid coxitis, MRI finds non-specific joint effusion and synovitis (Fig. 11). IV gadolinium injection is required to assess synovial proliferation. As well as the above signs, MRI may later show subchondral erosion and bursitis and/or synovial cyst.

In ankylosing spondylarthritis, abnormality may be limited to simple joint effusion. MRI sometimes finds inflammatory sacroiliitis (Fig. 12).

4.5. Septic arthritis

Plain radiographs are at first normal, despite functional impairment. Joint-space narrowing involves the entire joint-line, with early onset (2nd week), often associated with locoregional demineralization. Subchondral erosion then sets in, with deformity of the femoral head and acetabulum.

MRI, although very useful, especially at first, should not be a reason for delaying joint aspiration. It shows suggestive signs in a clinical and biological context of infection: effusion, synovial proliferation, medullary edema which may be very extensive, periarticular soft-tissue inflammation and sometimes soft-tissue abscess.

CT is easier to perform in case of intense pain. It shows joint-space narrowing, subchondral erosion, joint effusion and sometimes small periarticular abscesses (Fig. 13).

4.6. Microcrystalline and metabolic hip disease

ACC is usually asymptomatic, but may lead to RDO.

4.7. Synovial tumoral and pseudo-tumoral pathology

Villonodular synovitis (VNS) consists in benign synovial hyperplasia with hemosiderin deposits usually involving all or most of the synovium. Joint aspiration product is usually typical (serosanguineous fluid).

Plain radiographs may be normal, but usually reveal bone erosion or cysts (in 93% of cases). The erosion, which may be extensive, is bordered by sclerotic radiolucency and involves the non-bearing parts of the joint. Conserved joint-line and absence of osteophytes are important negative signs.

MRI is the key examination, revealing synovial proliferation, usually with areas of low signal on T2-weighted and especially...
Fig. 18. Stage-I bilateral osteonecrosis of the femoral heads: a–d: plain X-ray is normal; e, f: T1 and T2-weighted frontal slices: bilateral osteonecrosis with conserved sequestrum fat signal.

Fig. 19. Incipient osteonecrosis (stage IIa) of the right femoral head: a, b: plain X-ray: slight heterogeneity of the femoral head; c, d: coronal and sagittal CT slices: patchy sclerosis with sinusous head contours (arrow), highly suggestive of osteonecrosis; e, f: MRI, T1-weighted frontal and T2-weighted sagittal slices: clearly visible head necrosis, with sequestrum with conserved fat signal and reactive interface of low-intensity on T1 and high intensity on T2-weighted sequences (arrow).

T2* gradient-echo sequences, due to the presence of hemosiderin. If MRI is not available, CT arthrography finds sanguineous aspiration fluid and synovial proliferation without intra-articular foreign bodies (Fig. 14).

Primary synovial osteochondromatosis is a form of synovial chondrometaplasia resulting in cartilaginous bodies, which may ossify.

Plain X-ray detects nodules only if calcified. It mainly reveals multiple bone erosion caused by the pressure induced by the nodules. There may be enlargement of the joint-line. OA is late.

Diagnosis is founded on or confirmed by CT arthrography or MRI (Fig. 15), showing synovial proliferation and, above all, multiple small foreign bodies released into the joint.

4.8. Paget’s disease of the hip

Diagnosis is often serendipitous, on CT or bone scan performed for some other reason. The acetabulum, femur or both are involved. Evolution is slow, involving joint-space narrowing with few osteophytes (Fig. 16). Coxa vara or acetabular protrusion is frequent.
4.9. Rare and controversial diagnoses

Round ligament fissure or tear is sometimes found on MRI or MR arthrography, without history of dislocation [18]. The significance is a matter of debate.

Non-traumatic micro-instability of the hip is a controversial concept that may be applicable in athletes' hip (Fig. 17). It is said to be related to congenital or acquired laxity in high-level athletes. It is associated with capsule distension or round ligament lesion, and may induce labral tear.

5. Bone pathology

MRI is the examination of choice [19] (Fig. 1). CT may be a useful complement, especially in tumor.

5.1. Aseptic osteonecrosis of the femoral head

In nascent forms, diagnosis is based on MRI, which is the most sensitive (sensitivity approximating 100%) and specific examination (specificity >90%) (Fig. 18). Various classifications have been
described; the modified Arlet and Ficat classification is the most widely used (Table 4) [20].

MRI is indispensable, even if diagnosis is clear on plain X-ray (grades III and IV). T2-weighted sagittal acquisitions determine sequestrum size and location and screen for infra-radiological contralateral involvement. Only in bilateral grade III or IV is MRI not worthwhile.

MRI finds necrotic bone or a sequestrum contoured by a reactive interface between necrotic and healthy bone (Fig. 19), showing as a concave continuous rounded or sinuous line joining the two sides of the subchondral plate on T1 and T2-weighted sequences. This line is of low signal intensity on T1-weighted images and is either hypointense or hyperintense on T2-weighted images. A double line was first reported, but was in fact artifactual and is not seen when the fat signal is suppressed.

The sequester signal is variable: fatty or heterogeneous. It is usually located in the anterosuperior cephalic quadrant and may extend to the posterosuperior quadrant.

Table 4

<table>
<thead>
<tr>
<th>Stage</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage I</td>
<td>Normal X-ray</td>
</tr>
<tr>
<td>Stage IIa</td>
<td>Femoral head heterogeneity</td>
</tr>
<tr>
<td>Stage IIIb</td>
<td>Suggestive crescent-shaped densification; conserved femoral head sphericity, normal joint-line and acetabulum</td>
</tr>
<tr>
<td>Stage III</td>
<td>Subchondral bone-plate rupture with clear subchondral crescent over a dense triangular area of necrotic bone, giving an “egg-shell” aspect; then loss of femoral head sphericity, with flattening or local detachment</td>
</tr>
<tr>
<td>Stage IV</td>
<td>Joint-space narrowing and secondary osteoarthritic remodeling</td>
</tr>
</tbody>
</table>

On MRI, the “egg-shell” aspect is seen as a liquid signal line under the subchondral plate. The rest of the femoral head shows medullary edema in 30–40% of cases, sometimes involving the neck. Joint effusion is frequent. These anomalies are frequently associated with hip pain.

![Fig. 22. Rapidly destructive osteolysis in a 77-year-old female: a, b: initial radiographs: subluxation of the femoral head; c–g: plain X-ray, CT and MRI 3 weeks later: femoral head and neck destruction associated with major hematic effusion containing bone sand (arrow). Note bone sand migration into psoas muscle (arrowhead).](image)

![Fig. 23. Acetabular metastasis in a 47-year-old male with bronchial carcinoma: a: plain X-ray and CT: osteolysis of the back of the acetabulum (white arrow); c: MRI clearly showing joint invasion (arrowhead).](image)
5.2. Transient medullary edema (TME), transient osteoporosis, bone insufficiency fracture

TME and transient osteoporosis are a single entity, associating pain and osteopenia, hyperfixation on bone scan and medullary edema on MRI. These signs are not synchronous: abnormalities appear earlier on MRI and bone scan than on plain X-ray. TME mainly affects men in their 40s and women in the third trimester of pregnancy or in the immediate post-partum period.

TME may be induced by trabecular fracture [21]. However, TME related to bone insufficiency fracture with confirmed osteoporosis is to be distinguished, as evolution may be more unfavourable (Figs. 20 and 21).

Radiologic abnormalities appear some weeks after symptom onset and progressively resolve over a few months: severe osteopenia of the femoral head, femoral neck and sometimes acetabulum, disappearance of the subchondral plate, and normal joint-line.

MRI finds abnormalities as of the first week following symptom onset [22], with 5 positive signs: generally intense medullary edema involving a large part of the femoral head and sometimes the acetabulum, hypervascularization of the subchondral plate, which is not to be confused with an “egg-shell” aspect, trabecular micro-fracture(s), joint effusion and synovitis, and capsule and periarticular contrast uptake. The negative signs are important: there is no joint-space narrowing or bone destruction (Fig. 20).

Non-weight-bearing is recommended in the great majority of cases; the abnormalities resolve within months, without

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**Fig. 24.** Osteoid osteoma of the acetabulum in a 47-year-old male, overlooked on initial examination: a: initial MRI: joint effusion and medullary edema of the posterior wall; b, c: optimized MRI, T-2 weighted gadolinium-enhanced sequence: probable nidus (arrow); d–g: sagittal angio-MRI sequence: early intense nidus uptake (arrow) followed by washout. The medullary edema area shows progressive uptake and, after a few minutes, the nidus can no longer be detected. This is why dynamic sequences are preferable to conventional contrast-enhanced sequences; h: graph of nidus and medullary edema area uptake, showing progressive equalization of nidus and medullary edema area uptake.

**Fig. 25.** Ultrasound scan (longitudinal section) showing gluteus medius tear (dotted line) in a 74-year-old female. GT: greater trochanter.
sequelae, but may successively involve several lower-limb joints, over a period of usually less than 1 year.

5.3. Rapid osteolysis of the superior extremity of the femur

Rapid destructive osteolysis is rare. Initial plain radiographs are normal, but destruction of the superior extremity of the femur sets in rapidly, although the joint-line is conserved overall. There is typically bone sand in the joint-line and adjacent muscles (Fig. 22).

5.4. Bone tumor and pseudo-tumor

In adults, the most frequent tumoral lesion of the femoral metaphysis or acetabulum is metastasis, most often of bronchial or upper-airway origin (Fig. 23). Femoral head (epiphyseal) lesions are rarely tumoral; the most frequent epiphyseal tumors are chondroblastic (before 20 years of age), giant-cell tumor clear-cell chondrosarcoma, osteoid osteoma and chondroma.

MRI is the best means of locating the tumor precisely, determining its anatomic relations and dimensions and characterizing it. Intense medullary edema, relatively large with respect to the size of the lesion, suggests a benign process [23]. CT may also be useful for characterizing the lesion and assessing bone texture.

Intra-articular osteoid osteoma is difficult to diagnose, and late diagnosis is very common. Symptoms are rarely specific; there is often synovitis and sometimes OA. In lesions less than 1 cm from the joint surface, the characteristic bone sclerosis and bonyseal hyperfixation are lacking. On MRI, medullary edema is generally intense, masking the nidus if image quality is not optimal. In the absence of any other bone abnormality, medullary edema suggests osteoid osteoma and should lead to dynamic acquisition with IV gadolinium injection and/or CT scan (Fig. 24).

6. Abarticular pathology

Abarticular hip pathologies are often classified by location: anterior, lateral, or posterior. Traumatic and micro-traumatic tendon-muscle lesions mainly involve the hamstring, iliopsoas, femoris rectus and adductor tendons. Degenerative tendinopathy in elderly subjects mainly involves the gluteus minimus and medius; degenerative tendon tears tend to go overlooked. Enthesopathy is frequent and may involve numerous pelvic entheses. Hip snap is usually tendinous, more frequently anterior (iliopsoas) than lateral (iliotibial band and gluteus maximus).

Diagnosis is clinical. Plain X-ray and ultrasound assessment are usually enough to confirm diagnosis and rule out other pathology [24] (Figs. 1 and 25). MRI is indicated in case of radiological/clinical discordance, severe sports trauma (where it provides better topological analysis) and ischiofemoral impingement, which is not well explored on ultrasound (Fig. 26).

Ischiofemoral impingement is only recently identified as such, and is due to shrinkage of the space between the ischial tuberosity and lesser trochanter. It induces deformity, edema and quadratus femoris muscle tear or atrophy; sciatic nerve irritation may ensue. Plain X-ray looks for bone abnormalities that could account for the impingement. MRI is the key examination (Fig. 26).

7. Conclusion

In painful hip, diagnosis is above all founded on painstaking clinical examination and plain X-ray assessment.

Following plain X-ray, ultrasound is the first exploration to be performed in abarticular pathology: MR arthrography and/or CT arthrography are indicated in suspected FAI or labral tear. In all other cases, MRI is indicated.

As CT radiation levels have fallen and hybrid techniques (FNa PET scan, PET-MRI) have been developed, the respective roles of the various examinations will change in the near future.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References


