Reumatología Clínica

Continuing medical education

Imaging studies in cases with painful shoulder☆

Enrique Ramón Botella, a,* Luis Hernández Moreno, a and Antonio Luna Alcalá b

a *Servicio de Radiodiagnóstico, Hospital General Universitario Gregorio Marañón, Madrid, Spain*
b *Servicio de Radiodiagnóstico, Clínica las Nieves, Jaén, Spain*

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ABSTRACT

Painful shoulder is a frequent clinical problem in musculoskeletal pathology. Imaging plays an essential role in the etiologic diagnosis. Simple x-rays are usually the first performed diagnostic test, and on occasion, it is enough to establish a diagnosis. Tendinous calcifications are clearly depicted on plain radiographs, which are a first option modality in the evaluation of bone tumors. Tendinous pathology is the most common cause of shoulder pain. It may be analysed either by ultrasound or magnetic resonance (MR). MR is the most sensitive technique to detect early pathological changes. MR is usually used in the presurgical evaluation of the shoulder and in local staging of bone and soft tissue tumors.

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Estudio por imagen del hombro doloroso

RESUMEN

El hombro doloroso es un problema clínico frecuente en la enfermedad osteomuscular. Las pruebas de imagen desempeñan un papel importante en el diagnóstico etiológico. La radiografía convencional generalmente es la primera prueba realizada y en ocasiones es suficiente para el diagnóstico. Las calcificaciones tendinosas se ven con claridad y en el diagnóstico etiológico de las neoplasias óseas las técnicas tomográficas no la han sustituido. La patología tendinosa es la causa más frecuente de dolor en el hombro, y tanto la ecografía como la resonancia magnética (RM) son herramientas eficaces para su estudio. La RM es la técnica que mejor detecta cambios patológicos precoces. Asimismo, es fundamental en la valoración prequirúrgica del hombro y en la estadificación local de los tumores óseos y de las partes blandas.

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Introduction

The painful shoulder is one of the most prevalent problems in osteomuscular diseases and, from an imaging standpoint, can be approached with different diagnostic techniques. The initial approach is usually performed with a simple x-ray (SXR) but generally, with the exception of some trauma or calcifying tendinopathy, must be complemented with tomographic techniques, ultrasound (US), or magnetic resonance (MR). This review article will attempt to summarize the most relevant aspects of the different techniques of imaging diagnosis in the case of the painful shoulder and establish its role in the most frequent clinical presentations.

Examination methods

Shoulder x-ray[1]

The recent development of other techniques, such as US, computerized tomography (CT), and MR have not managed to eclipse SXR, making it still the most requested image test when evaluating shoulder pathology.

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* Corresponding author.
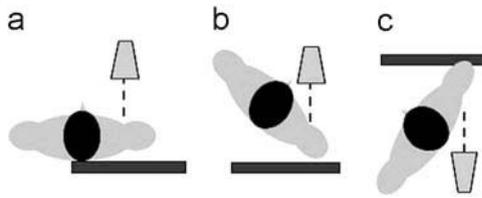*E-mail address:* erbhgugm@yahoo.es (E. Ramón Botella).

Figure 1. a) Anteroposterior projection. b) Tangential projection. c) "Y" projection.

Its main disadvantages are related to its low capacity to detect soft-tissue lesions (with the exception of tendinous calcifications), localizing cartilage or glenoid labrum lesions and detecting pleural effusions. However, it is the main diagnostic method for the initial diagnostic evaluation of bone tumors and for the evaluation of pain due to acute trauma.

The anteroposterior projection is the one most commonly employed in the radiological evaluation of the shoulder. The subject can be examined while standing up or lying down. Another common projection is the tangential one in which the subjects adopts a posterior oblique position at 40°. This projection allows for an optimal tangential vision of the glenoid cavity. The third most commonly employed projection is the one known as a "Y" projection. The subject adopts an oblique position with the anterior face of the examined shoulder next to the chassis. The acromion can be clearly seen in this projection.

Figure 1 shows the 3 most frequent projections.

Ultrasound[2]

The echographic examination of the shoulder has many advantages compared with the rest of the imaging techniques. It is not invasive, has a good spatial resolution and is cheap. It has a limited value in the observation of the cartilage and is not useful to evaluate intraosseous alterations. Tendinous pathology is easily approachable and allows for the evaluation of joint liquid.

Current transducers use frequencies in the range of 5 to 13 MHz and allow permit the achievement of a spatial resolution of up to 0.2 mm, which is superior to the resolution reached by current MR protocols.

Magnetic resonance[3]

MR is an excellent imaging method to evaluate shoulder disease. It allows for the optimal evaluation of all anatomical structures: glenoid cavity, humeral head, cartilage, acromion, muscles, tendons, labrum, and glenohumeral ligaments in multiple planes. The examination protocols must include protonic density images, T1 and T2 sequences. Images in T1 and protonic density have the highest signal to noise ratio and produce an elevated spatial resolution. On the other hand, T2 images are sensitive to pathological alterations, especially when they are combined with fat suppression techniques.

The examination protocols contemplate oblique coronal and sagital panes, as well as parallel and perpendicular planes to the trajectory of the supraspinous tendon respectively, as well as axial planes. The coronal projection fundamentally evaluates the supraspinous muscle and tendon, the subacromial space, the subdeltoid bursa, and the acromioclavicular joint. Sagital studies evaluate muscles and tendons of the rotator cuff, the oracoacromial arch, and the acromial morphology. Axial images allow for the fundamental evaluation of the labrum and part of the biceps. MR arthrography can readily detect problems affecting the labrum and the glenohumeral ligaments and is mainly indicated when studying glenohumeral instability.

Computerized tomography

Although the development of other tomographic techniques (US and MR) have reduced the number of examinations performed using CT in the evaluation of the shoulder, there are still some indications.

SXR is still the first choice for imaging of trauma of the shoulder. However, the superposition of structures on occasion impedes the observer to make out optimal details of the bony alteration. CT is an excellent method for the evaluation of bone fragments, dislocations, and free bodies in the joint cavity. It is also a test of choice for the diagnosis of osteoid osteoma and in the study of osteomyelitis in which performing small cuts can demonstrate the nest and sequestered fragments.

Post-processing of the studies obtain with modern tomographs (multi-cut helicoidal) permits the radiologist to reconstruct images in different spatial planes and obtain 3-dimensional models.

Rotator cuff pathology

The syndrome of subacromial impingement is the result of painful compression of the supraspinous tendon, the subacromiodeltoid bursa and the tendon of the long portion of the biceps between the humeral head and the anterior portion of the acromion during abduction and the elevation of the arm in internal rotation.[4]

To understand the cause of te subacromial syndrome it is important to know the anatomical characteristics of the subacromial space. The acromion, the coracoacromial ligament, and the coracoid process form the superior border. The acromioclavicular joint has a supero-posterior localization. The humeral head forms the inferior border (Figure 2).

The causes of this syndrome can be intrinsic (or intratendinous) or extrinsic (or extratendinous). Muscle weakness and overwork as well as degenerative tendinopathy are the most frequent intrinsic causes. Acromioclavicular arthritis, glenohumeral instability, coracoacromial ligament hypertrophy, and the acromial morphology are implicated as extrinsic causes of the syndrome.

Any of the causes produces changes in the structures localized in the subacromial space. The supraspinous tendon is the most frequently affected; however, pathological changes can develop without evidence of mechanical or structural causes, in other words, as an intrinsic cause of the syndrome.

The formation of degenerative bone cysts, mainly over the greater tuberosity of the humerus, can precede the appearance of changes in the rotator cuff tendon.

Finally, subacromial deterioration can irritate the subacromiodeltoid synovial bursa, which appears distended by fluid. Stage I tendinous pathology consists of edema and hemorrhage in
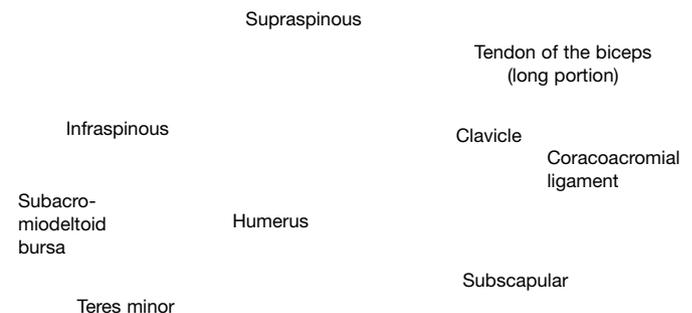

Figure 2. Anatomical depiction of the subacromial space.

the distal portion of the tendon. Stage II is characterized by tendinous degeneration: tendonitis or tendinosis. In addition, there are no inflammatory changes. Stage III is shown as partial or complete tendon rupture.

Although the evaluation of the painful shoulder can begin with an x-ray, this has limited diagnostic value. An acromioclavicular interval of less than 7 mm (normal, 8-12 mm) indicates thinning of the supraspinous tendon due to degeneration or rupture. Echography is an excellent diagnostic method for tendon evaluation.[2,5] In cases of tendinosis, the tendon shows a heterogeneous hypoechogenicity. A partial rupture affecting the superior surface leads to the loss of tendon convexity and a flattening of this. When the tear is localized to the joint surface it can appear as a hypoechoic defect. The existence of bone irregularities on the larger tuberosity is a secondary sign of tendon rupture. The sonographic sign of a complete tear is the focal defect of the tendon or the absence of it (Figure 3).

Probably, MR is the diagnostic imaging test of choice in the evaluation of the painful shoulder.[3,6] A normal tendon is hypodense in all of the sequences. Tendinosis is shown as focal or diffuse areas with a hypersignal in T1 sequences and protonic densities and a maximal hypersignal to the muscle signal in T2 sequences. As the signal in T2 sequences in pathologic areas reaches the signal of fluid, the diagnosis of a tear is more likely. The tear is partial when the interruption in the continuity does not affect the whole width of the tendon and is complete when it affects all of the tendon fibers, from the joint surface to the surface of the synovial bursa (Figure 4).
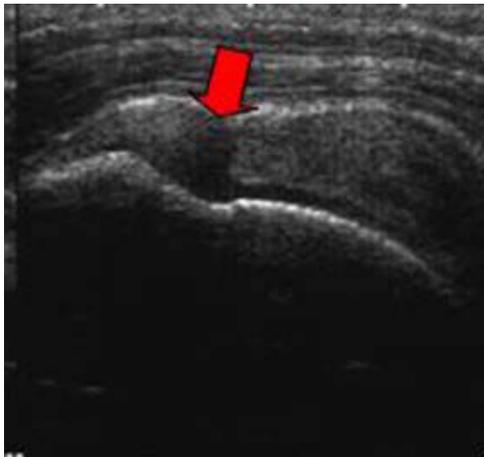

Figure 3. Echography: complete tendon rupture. The arrow shows a lack of continuity.

Most of the tendinous tears affect the supraspinous tendon. Isolated tears of the infraspinous or subscapular tendons are rare and generally occur in combination with a supraspinous tendon tear. The detection of pathological changes in the tendon before the development of a complete tear is important because the clinical picture can be controlled with conservative treatment, debridement and decompressive surgery. Complete tears, in addition to producing pain, limits movement and requires more intensive surgical treatments.

Instability syndrome[7,8]

Glenohumeral instability follows in frequency the subacromial syndrome and frequently coexist. Instability consists of a traumatic dislocation or in spontaneous dislocation of the humerus. It is a cause of painful shoulder that, with the exception of the acute episode, can be a difficult diagnosis.

The main elements of stability of the glenohumeral joint are the following: the capsule, the glenoid labrum, and the glenohumeral ligaments, mainly the inferior glenohumeral ligament.

The anterior dislocation is the most frequent type of instability. In these cases, the impact on the glenoid can produce a fracture of the superior region of the humeral head: Hill-Sachs fracture (Figure 5). A characteristic fracture can also be produced in the anteroinferior region of the glenoid: Bankart's fracture (Figure 6). Bankart's fracture must be differences of Bankart's lesion which consists of a tear or an avulsion of the asnteroinferior region of the labrum and the glenoid periostium during an episode of anterior shoulder dislocation.

The second injury of the labrum related to the syndrome of intestabilidad is a variant of Bankart's injury: the injury ALPSA (anterior labroligamentous periosteal sleeve avulsion) in that the periosteum remains intact.

Arthritis[9,10]

Evaluating through imaging the clinical context of arthritis usually starts with a SXR. It is a widely available, low cost technique. However, it does not permit the evaluation of soft tissue or the direct observation of cartilage or synovial bursa; in addition, it has a low sensitivity for detecting early erosions. Echography allows the evaluation both of the cartilage as well as the synovial bursa. MR is the technique with the best resolution in contrast and is optimal for detecting early erosions.
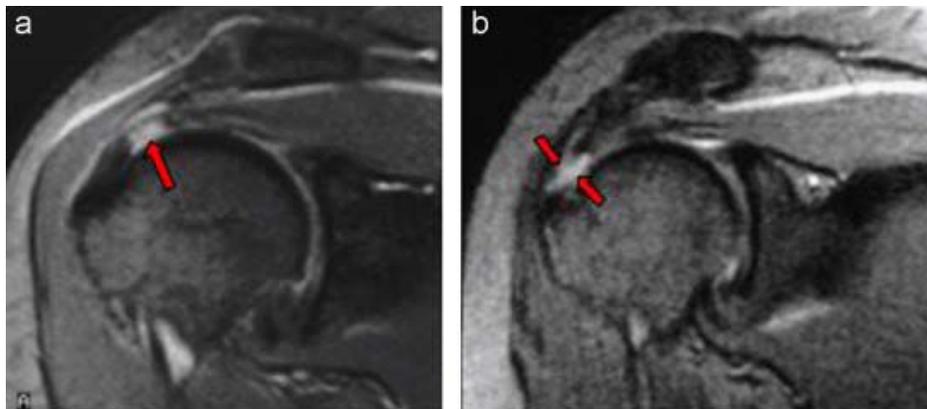

Figure 4. T2 sequences. Coronal oblique projection. Partial rupture of the supraspinous tendon which affects all of the inferior fibers (arrows in a). Complete rupture of the supraspinous tendon (arrows in a).
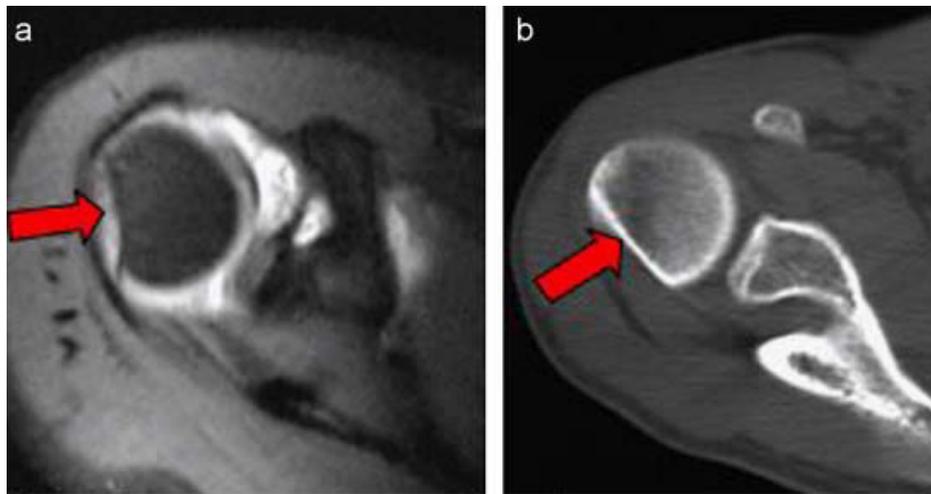
Figure 5. a) Axial cuts on magnetic resonance. b) Computerized tomography of the shoulder. Hill-Sachs' fracture (arrows).
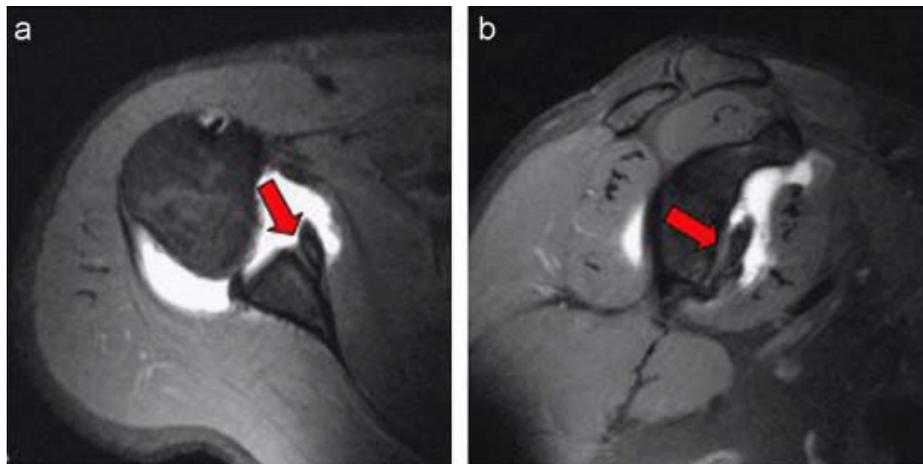

Figure 6. Magnetic resonance arthrography. a) Axial view of the shoulder. b) Sagital view of the shoulder. Bankart's fracture (arrows).

Osteoarthritis

Typical findings of osteoarthritis are narrowing of the joint space, the formation of osteophytes, bony sclerosis, subchondral cysts, and osteochondral free bodies. Acromioclavicular osteophytes are a frequent cause of the subacromial syndrome.

Rheumatoid arthritis

When the shoulder is affected by rheumatoid arthritis, erosions tend to be more frequent in the superolateral region of the humerus (adjacent to the larger tuberosity) and can simulate a Hill-Sachs fracture. If the acromioclavicular joint is affected, the most prominent findings occur on the clavicular component and can lead to the destruction of the distal end of the clavicle in later stages.

Seronegative arthropathies

The shoulder can be affected in ankylosing spondylitis and psoriatic arthritis. Bone erosions also predominantly affect the superolateral region of the humerus (Figure 7).

Figure 7. Anteroposterior x-ray of the shoulder. Psoriatic arthritis: bony erosions (arrows).
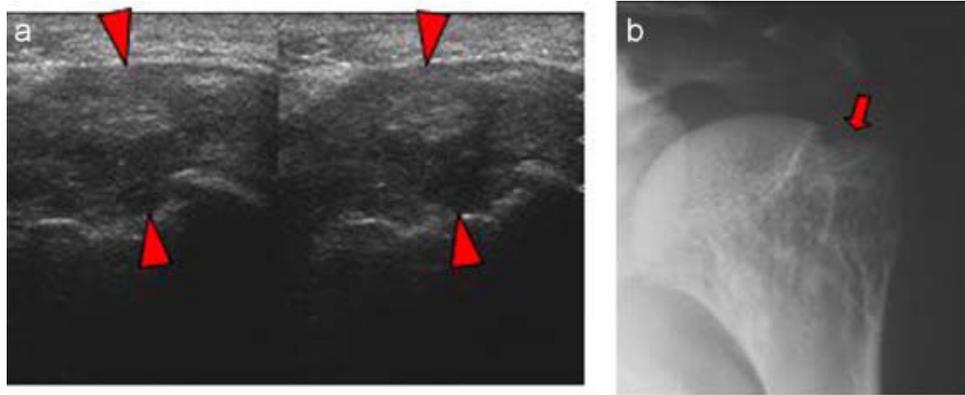
Figure 8. Amyloid deposit. In the echography (a) there is an occupation of the joint space due to hyperechogenic material which corresponds to an amyloid infiltrate (arrowheads). The anteroposterior x-ray (b) shows a bony erosion (arrow).
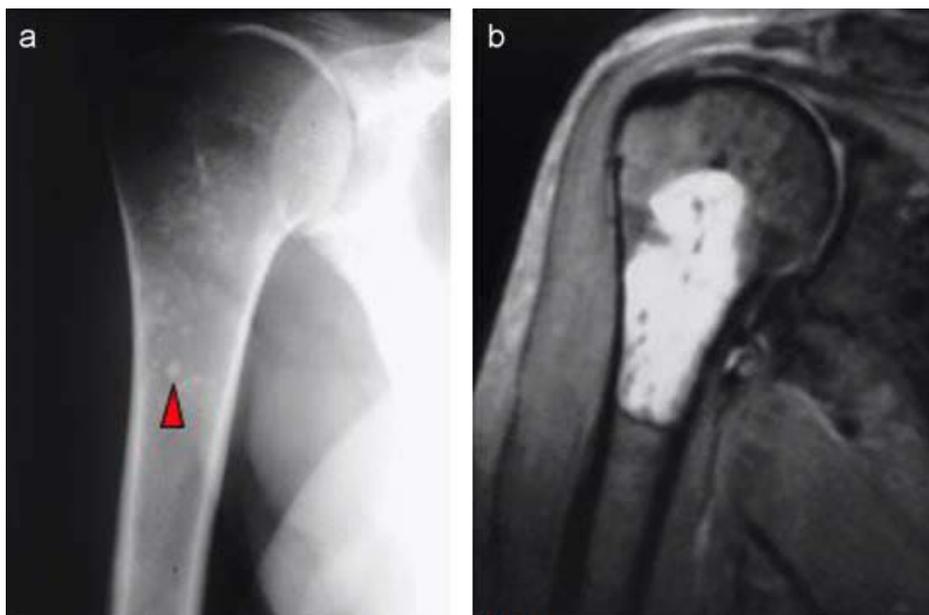

Figure 9. Enchondroma. Anteroposterior x-ray (a) in which the characteristic calcifications of the chondroid lesions can be (arrowhead). Magnetic resonance of the same lesion (b).

Amyloidosis

Amyloid deposits can be produced around the larger joints and lead to an important degree of inflammatiuon and pain. Bone erosions are characteristically extensive (Figure 8).

Infectious arthritis

In the presence of a monoarticular inflammatory process it is important to consider a diagnosis of septic arthritis. There are certain predisposing factors: diabetes, steroid treatment, parenteral drug use, etc. The suspicion diagnosis is clinical. Joint fluid aspiration and its culture can lead to the diagnosis. In addition, arthrocenthesis can by guided by ultrasound.

A bacterial infection is responsible in most of the cases, mainly due to *Staphylococcus aureus*. Often, in bacterial infections, the cartilage and bone destruction occur rapidly. In tuberculosis cases or fungal infections, changes are slower.

X-rays are often the first method of exploration. However, they are of limited value because in initial studies changes are limited to soft tissue. Echography and MR are more sensitive for detecting early alterations because they can detect low amounts of joint fluid and synovial thickening. MR is especially useful for the demonstration of bone edema through fat suppression sequences.

Tumors[11]

The shoulder is the second most common localization after the knee for musculoskeletal tumors. The most commonly detected tumor of the shoulder is an enchondroma, generally in an incidental way. Chondrosarcoma is the most frequent malignant primary tumor. Myeloma and metastasis are the metastatic malignancies which occur more frequently in the shoulder. SXR is the most useful technique for establishing a differential diagnosis of a bone tumor and permits the answer to questions used for the definite diagnosis: what part of the bone is affected?, what is the pattern of destruction?, is there a periostic response?, what type of mineralization is present?

Osteosarcoma is originated in the metaphisis or metadiaphisis, licalizations with a great cell turnover during adolescence. An epiphisal lesionduring childhood reduces the differential diagnosis to chondroblastoma and eosinophilic granuloma. In adults, this
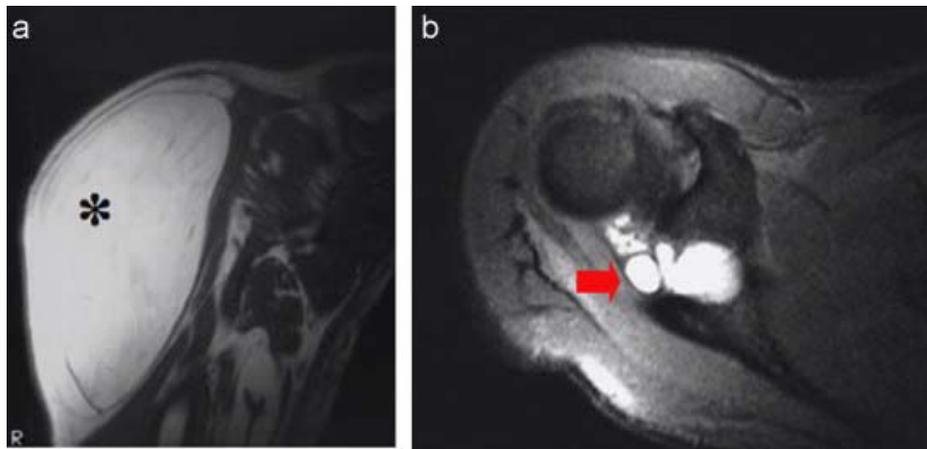
Figure 10. T1 sequence (a): fatty tumor (asterisk). Axial sequence T2 (b): paralabral cyst in the spinoglenoid notch (arrow).

localization suggests that the diagnosis is a giant cell tumor, a chondrosarcoma, or an intraosseus ganglion.

The analysis of the transition zone with healthy bone allows for the estimation of the tumoral process. The more radical the tumor, the wider the transition zone. Bone destruction in a geographic morphology makes reference to slow growth and less invasiveness; this is the case of fibrous dysplasia or enchondroma.

The permeating pattern of bone destruction is frequent of invasive lesions: osteosarcoma, Ewing's sarcoma, and metastasis.

Periosteal reaction, when present, also helps with the differential diagnosis. A "shell-like" reaction is evidence of it being benign. Periostic laminating ("onion skin") is observed in malignant or invasive lesions.

The matrix or intercellular substance produced by tumors can calcify or ossify and be a key to the diagnosis (Figure 9).

The soft tissue of the shoulder can also harbor tumors. The lipoma is the most common benign tumor of the shoulder. Fibrohistiocytoma and liposarcoma are the most common malignant lesios. MR is especially useful in the detection of a soft-tissue tumor because it defines its extension and maps out the biopsy. The signal characteristics of the soft-tissue tumors are not specific enough to establish a histologic diagnosis or even to distinguish between benign lesions from malignant ones, with the possible exception of lipomas, hemangiomas, paralabral cysts and, possibly, elastofibromas (Figure 10).

The main role of CT and MR in the treatment of musculoskeletal tumors is staging. MR is especially useful to determine the local extension of the tumor due to its better contrast resolution.

Conclusions

Imaging of the painful shoulder should start with an anteroposterior SXR. This initial evaluation can be enough in some cases of trauma and calcifying tendinopathy. It is also the technique of choice for the diagnostic evaluation of bone tumors. However, it has some limitations in the demonstration of soft-tissue alterations.

Echography permits the study of tendon pathology with a diagnostic accuracy similar to that of MR. This study is chosen in a subject with suspected rotator cuff pathology and a negative conventional x-ray. It is also a useful tool to guide invasive procedures. In addition, it is also a widely available technique and very competitive from the economic standpoint.

MR allows for the optimal observation of all of the anatomical structures of the shoulder. Through different sequences and projections, it is possible to practically study all of the pathological processes that can affect the shoulder and fundamentally in their early stages of progression. It is indicated in those subjects with rotator cuff rupture in which surgery is contemplated. MR allows the clinician to evaluate exactly the size of the rupture, tendon retraction and the degree of muscle atrophy, useful data for the surgeon when panning the intervention. It is the technique of choice for the evaluation of glenohumeral instability and for the local staging of bone and soft-tissue tumors.

Annex

1) ¿Which of the following magnetic resonance (MR) sequences is most useful when approaching the diagnosis of a tendon rupture?

a. T1
b. T2
c. Protonic density
d. T1 and T2

2) In shoulder arthropathies one can find erosions. Which is the most frequent localization?

a. Posterolateral region of the humeral head
b. Inferolateral region of the humeral head
c. Superolateral region of the humeral head
d. Glenoid

3) ¿Which of the following imaging techniques has a greater capacity to detect early change in infectious arthritis?

a. Echography
b. Computerized tomography
c. X-rays
d. Magnetic resonance

4) ¿Which is the technique of choice for the diagnosis of bone tumors?

a. Echography
b. Computerized tomography
c. X-rays
d. Magnetic resonance

5) ¿Which is the technique of choice of the local staging of bone tumors?

a. Echography
b. Computerized tomography
c. X-rays
d. Magnetic resonance

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