Imaging for patients presenting with a painful shoulder

Abstract

Shoulder pain is a common cause of musculoskeletal presentation in primary care, where both traumatic and atraumatic pathologies can also lead to emergency department attendances. This article discusses common acute and chronic presentations of a painful shoulder, looking at the typical history of patients presenting with a painful shoulder, examination findings and the most appropriate imaging modalities to consider. Strengths and weaknesses of each imaging modality are discussed along with their role in aiding diagnosis, as well as management of the various pathologies encountered in primary and secondary care.

Key words: Arthralgia; Imaging; Orthopaedics; Radiology; Shoulder

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Introduction

Shoulder pain constitutes 2.4% of all primary care consultations in the UK, with an estimated 1% of adults presenting with this to their GP each year (Thomas et al, 2016). These patients also commonly present to the emergency department with a variety of traumatic and atraumatic pathologies.

The history of any patient presenting with shoulder pain should include the age of the patient, hand dominance, occupation, any traumatic events, social history and levels of physical activity. Other key questions include the presence of night pain, impact on activities and whether the pain radiates from the neck towards the shoulder, which may suggest underlying cervical spine pathology. Furthermore, associated symptoms including stiffness, instability and weakness need to be checked, and a thorough past medical history may reveal comorbid conditions with strong associations to musculoskeletal pathology (Limb, 2014). Red flags such as malignancy, infection or persistent dislocations should be ruled out (Thomas et al, 2016).

Imaging can be used to diagnose, treat and monitor outcomes following shoulder pathology. It encompasses a broad spectrum of modalities, including plain film X-ray, ultrasound, computed tomography and magnetic resonance imaging, each with their own strengths and weaknesses.

Anatomy of the shoulder on plain film

The main projections of the shoulder are antero-posterior, axial and y-view. Each view provides specific information, which helps to identify potential aetiologies of shoulder pain. It is useful to revise the normal anatomy of the common projections of shoulder radiography to improve interpretation and identification of the underlying pathology. For example, fractures can be identified on any view following the basic principle of ensuring the cortices of each bone are not disrupted. Dislocations (anterior or posterior) can be challenging to interpret because of overlapping structures seen particularly in the lateral view, and the two-dimensional nature of X-rays make it difficult to conduct an assessment in the antero-posterior view.

In addition to bony structures, it is important to review the surrounding soft tissues which may demonstrate calcification (in conditions such as dermatomyositis and scleroderma) and masses (either of primary soft tissue origin, or arising from the bony structures).

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The acutely painful shoulder

Proximal humerus fracture

Proximal humerus fractures represent approximately 5–6% of all fractures of the extremities, and can be secondary to high and low energy traumatic injury. The incidence of these fractures is higher in people aged over 65 years old, with women affected 2–3 times more than men (Handoll et al, 2015). The morphology of these fractures is variable, with the position of four main segments (humeral head, greater tuberosity, lesser tuberosity and humeral shaft) defined relative to each other (Beard et al, 2018).

On physical examination, there may be extensive bruising across the chest wall, arm and forearm, with pain and swelling. It is important to assess neurovascular function, especially the axillary nerve to ensure there is no injury to the surrounding neurovascular structures, while concomitant injuries should also be ruled out (Zachariasen et al, 2020).

For the majority of these fractures, anteroposterior and lateral X-rays are the most common during initial radiological assessment (**Figure 1**) (Handoll et al, 2015), although in up to 63% of cases, X-rays underestimate the number of fracture fragments. Thus, computed tomography can be useful in assessing occult fractures of the coracoid process or lesser tuberosity, which can be missed on conventional X-rays (Haapamaki et al, 2004).

Proximal humeral head fractures can also lead to secondary complications, including avascular necrosis of the humeral head (**Figure 2**). Comminuted and displaced fractures of the proximal humerus carry a well-established risk of humeral head infarction, as retrograde blood supply from circumflex humeral arteries is interrupted. Particular risks include anatomical neck fractures, fractures involving displaced greater and lesser tuberosities, or comminuted articular split fractures (Hertel et al, 2004).

Dislocation injuries

The glenohumeral joint is the most commonly dislocated joint in the human body, and has a bimodal age distribution, with the young adult population presenting with high impact traumatic injury and older patients typically sustaining lower energy injuries (Cutts et al, 2009).

Anterior dislocations account for 97% of traumatic shoulder dislocations (Brownson et al, 2015), where patients present with an abducted and externally rotated arm. Key questions and findings include enquiring about a traumatic event and whether the patient required formal reduction or if the dislocation reduced spontaneously. Assessing neurovascular status is vitally important, especially in the axillary nerve (Brownson et al, 2015).

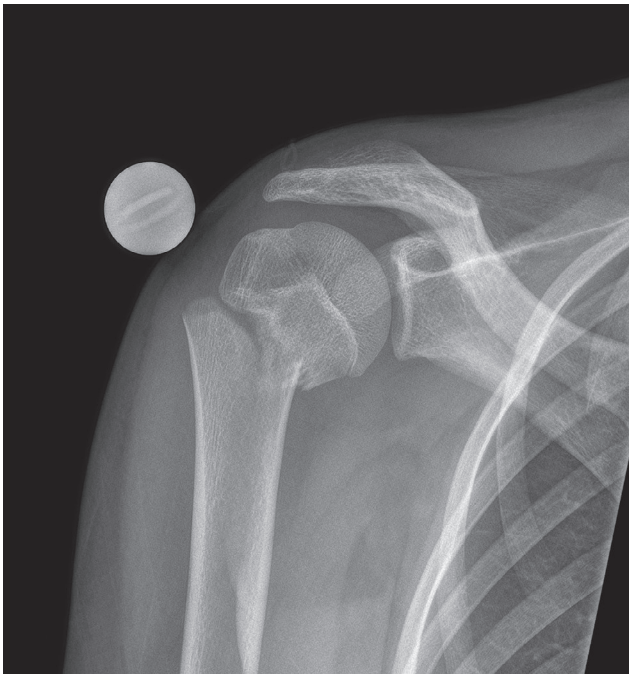

Figure 1. Antero-posterior X-ray of the right humerus, showing a displaced fracture of the proximal humerus.

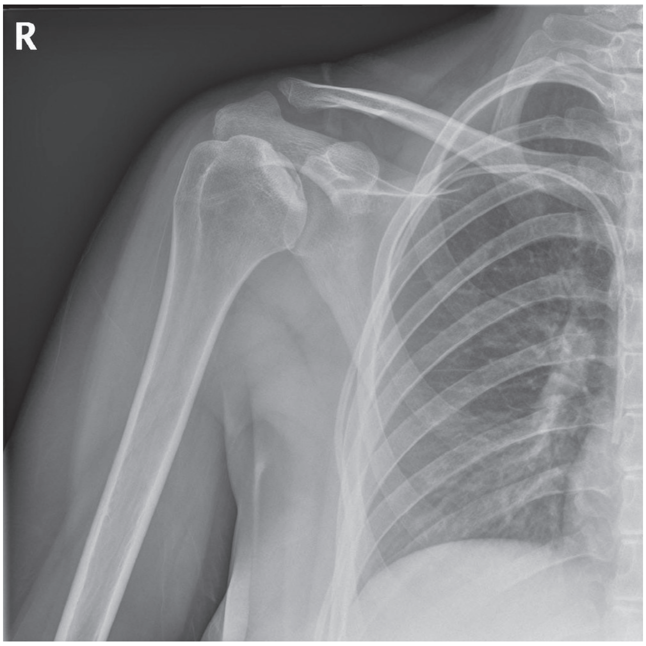

Figure 2. Antero-posterior X-ray of the right humerus, demonstrating flattening and sclerotic change of the right humeral head.

Imaging has an important role when confirming the type of dislocation and concomitant injuries. Given the mechanism of dislocation, secondary bony injury is common, thus antero-posterior and lateral views are warranted to assess for pathology. In anterior dislocation of the glenohumeral joint, there is sudden external rotation of the shoulder in abduction, thus pulling the humeral head out of the glenoid fossa. As the posterior aspect of the humeral head leaves the joint, it can cause avulsion of the anteroinferior labrum from the underlying glenoid fossa (Bankart lesion), or the anteroinferior aspect of the glenoid itself (bony Bankart lesion) (**Figure 3**). Additionally, as the posterior part of the humeral head exits the shoulder joint, it can collide with the anterior glenoid, causing a fracture of the humeral head – termed a Hill–Sachs lesion (Cutts et al, 2009).

Posterior dislocation is extremely rare, accounting for only 2–4% of all shoulder dislocations (Gor, 2002). It has classically been described in the context of seizures, and rarely, electrocution. In both of these cases, shoulder dislocation may be bilateral and should be considered during examination. Clinically, patients present with the arm held flexed, adducted and internally rotated, leading to an inability to externally rotate (Gor, 2002).

X-rays are the mainstay of imaging investigation. In particular, axillary and lateral views of the shoulder are vitally important, as posterior dislocations are not apparent on an antero-posterior projection in up to 50% of cases (Gor, 2002). While reverse Hill–Sachs (**Figure 4**) and reverse bony Bankart lesions may be evident; these are caused by the anterior part of the humeral head colliding with the posterior glenoid fossa, causing fracture of the humeral head and glenoid, and damage to the posterior labrum and soft tissues (Gor, 2002). These are best appreciated in the axial and coronal views of the shoulder (**Figure 4**). The Velpeau view is a useful alternative to the axial view when patients are unable to move their arm from an abducted position (often when immobilised).

Dislocation of the acromioclavicular joint occurs most commonly in young athletic adults, with an incidence of 3–4/100 000 in the general population (Allman, 1967). In direct trauma to the shoulder, forces act directly on the acromioclavicular joint and the coracoclavicular and acromioclavicular ligaments. Alternatively, in the case of a fall on the outstretched arm, there is indirect load on the acromioclavicular joint as a result of the humeral head pressing against the acromion.

On examination, patients typically present holding the upper limb in adduction for pain relief with limited mobility of the shoulder. The clavicle may be also appear elevated, with tenderness directly over the acromioclavicular joint.

Radiographic assessment where acromioclavicular joint dislocation is suspected should include a bilateral weight-bearing X-ray (Zanca view), where the patient holds a weight in the

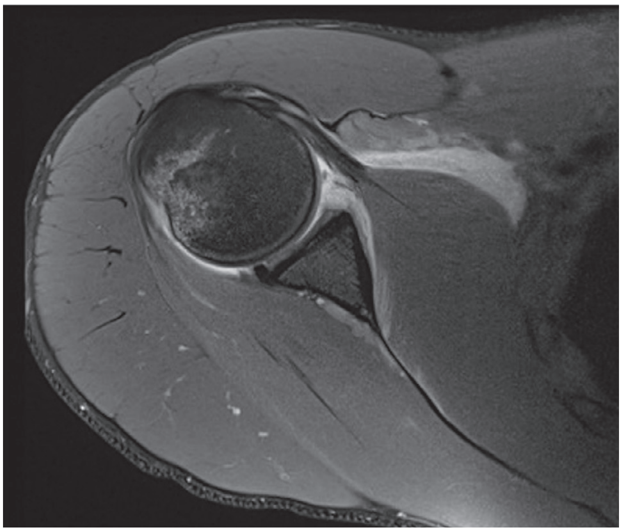

Figure 3. Axial T2-weighted image of the right shoulder. There is cortical irregularity at the postero-lateral aspect of the humeral head, associated with high signal within the bone marrow, in keeping with marrow oedema. These findings demonstrate a Hill–Sachs lesion.

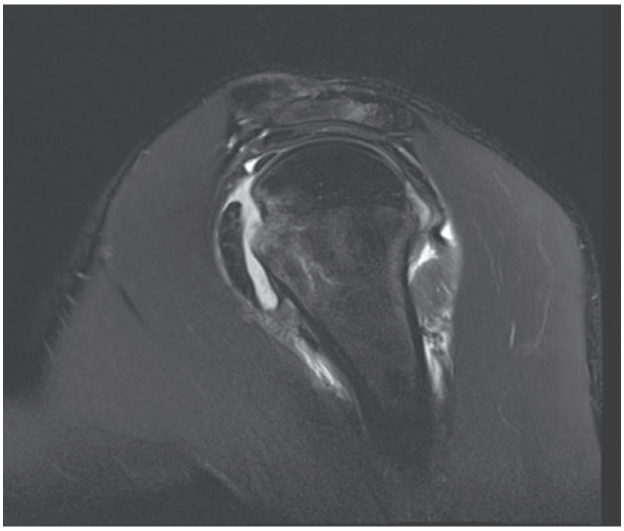

Figure 4. Coronal T2-weighted fat suppressed images of the left shoulder. There is a fracture of the medial aspect of the left humerus with associated high T2 marrow signal, in keeping with marrow oedema. This is an example of a reverse Hill–Sachs lesion.

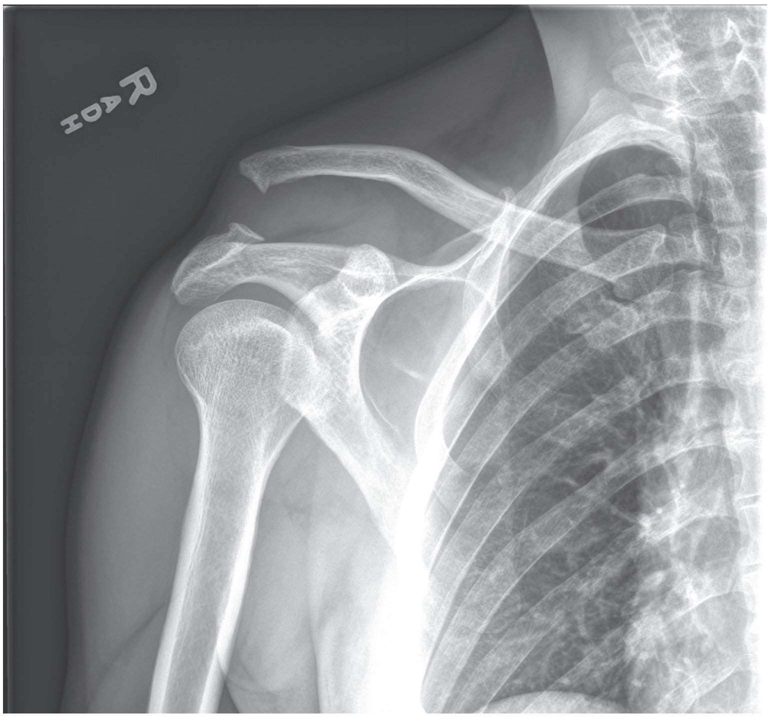

Figure 5. Antero-posterior shoulder X-ray demonstrates superior displacement of the lateral right clavicle in relation to the acromion, in keeping with acromioclavicular joint dislocation.

arms. This can accentuate acromioclavicular joint injury and make the diagnosis clearer in cases where initial antero-posterior X-rays appear normal, but clinical suspicion is high. Features on X-rays include soft tissue swelling, widening of the acromioclavicular joint (>8 mm), increased coracoclavicular distance (>13 mm) or superior displacement of the clavicle (Figure 5).

Rotator cuff tears

Acute rotator cuff tears may result in any form of traumatic shoulder injury. The incidence of acute full thickness rotator cuff tears is 2.5 per 10 000 in patients aged 45–70 years (Aagaard et al, 2015).

Early recognition and treatment is of paramount importance, as rotator cuff tears can have a profound impact on pain, sleep, leisure and psychological wellbeing (Minns Lowe et al, 2014). On examination, patients have a loss of active range of movement while passive movement is intact. There are over 25 special tests on examination for each of the four rotator cuff muscles demonstrate a loss of power (Limb, 2014). These include, Hornblower's sign, full can test, drop arm test, Jobe's test, Neer's sign, Hawkin's sign, and Speed's test (Jain et al, 2017). A detailed explanation of the examination findings is beyond the scope of this article.

Rotator cuff tear arthropathy is a specific type of glenohumeral degenerative disease, resulting from a massive rotator cuff tear leading to superior migration of the humeral head. Radiographs will demonstrate the classical radiological findings of arthritis as well as a reduced acromio-humeral distance (Ibounig et al, 2021). Treatment options include conservative management with lifestyle modification and physiotherapy, as well as more invasive management with corticosteroid injections and surgical options such as reverse arthroplasty (Thorsness and Romeo, 2016).

Either ultrasound or magnetic resonance imaging can be considered to evaluate the soft tissue structures surrounding the shoulder joint and the rotator cuff muscles. Given the high rate of rotator cuff tears in patients presenting with dislocation over the age of 40 years, the British Elbow and Shoulder Society (Brownson et al, 2015) recommend routine ultrasound or magnetic resonance imaging once radiographic imaging has been performed. Magnetic resonance imaging and ultrasound are both sensitive and specific in the diagnosis of rotator cuff full thickness tears (Figure 6) (Lenza et al, 2013).

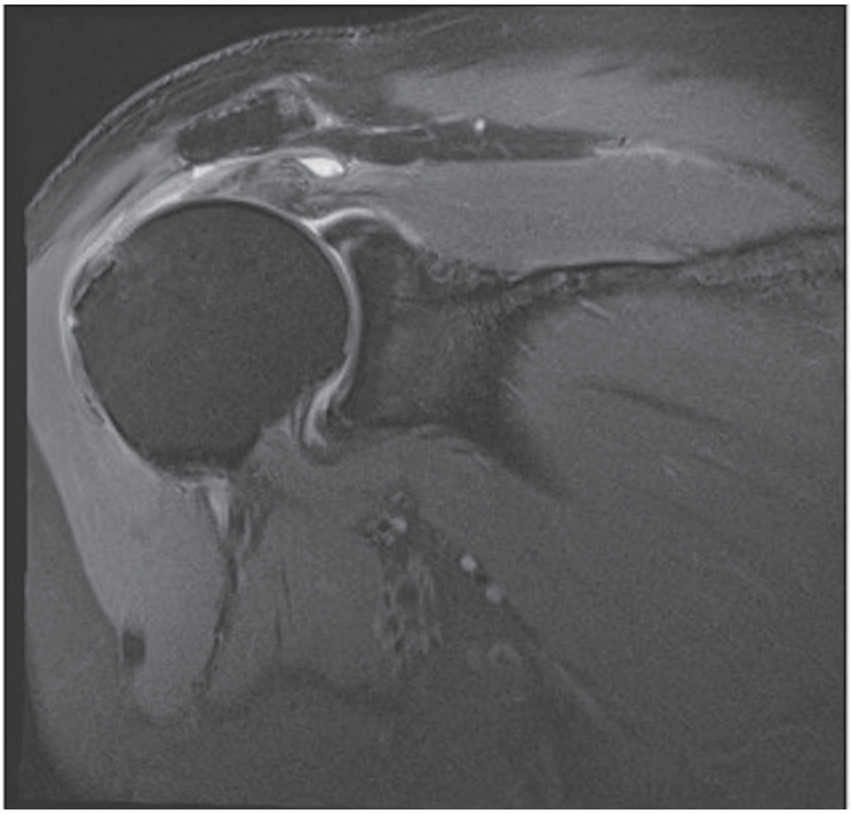

Figure 6. Coronal T2-weighted fat suppressed imaging shows a full thickness tear of the supraspinatus tendon.

Treatment and outcomes are determined by 'patient' and 'tear' factors, including the activity level of the patient and their age; whether the tear is acute or chronic, and the nature of the tear (eg size and depth) (Karjalainen et al, 2019). For most degenerative tears, non-operative management is the first-line treatment, including physiotherapy and analgesia.

Bursitis

Bursae are pouches containing synovial fluid, which are designed to alleviate friction between two opposing bony structures. Bursitis in the shoulder can be secondary to trauma, impingement and inflammatory conditions among others, and occur in conjunction with other pathologies, such as impingement and rotator cuff tears (Limb, 2014). They can cause significant pain and immobility of the shoulder joint, affecting quality of life of patients.

Plain X-rays are the most appropriate initial type of imaging, particularly in the context of trauma. Additionally, plain films may reveal the cause of the bursitis, such as degenerative disease of the shoulder joint, subacromial spurs or calcific tendonitis. Following this, ultrasound and magnetic resonance imaging should be considered.

Sonographic findings include fluid within the bursa, with a hyperechoic wall. Occasionally, there may be signs of synovial hypertrophy and increased vascularity around the shoulder joint. Ultrasound can identify debris and haemorrhage, which along with any intra-articular fluid, can be aspirated to aid clinical diagnosis, particularly where septic arthritis is suspected. During magnetic resonance imaging, a distended fluid-filled structure will be visible, which shows high T2 signal, low T1 signal and contrast enhancement of the synovial lining following gadolinium contrast injection (Kvalvaag et al, 2017).

Treatment can also be administered via ultrasound-guided steroid injection, which can provide pain relief and reduce inflammation (Messina et al, 2016). In addition to ultrasound-guided injections, non-operative treatments include oral anti-inflammatory drugs and physiotherapy. Where present, large calcific deposits within tendons (commonly the supraspinatus tendon) can be targeted and treated radiologically with barbotage (Figure 7). When non-operative options fail, surgical options that target the underlying cause may be needed. However, a randomised controlled trial in the UK found that surgical decompression offered no benefit over arthroscopy alone for patients with subacromial shoulder pain, raising the possibility that benefits from surgical management may be the result of placebo effects or that post-surgical patients benefit from postoperative physiotherapy (Beard et al, 2018).

The chronically painful shoulder

This is a common presentation in primary care, and has a significant impact on patient quality of life. The chronically painful shoulder can present a diagnostic and therapeutic challenge for primary care physicians because of the complex combination of symptoms and the recurring nature of these conditions.

Adhesive capsulitis

Adhesive capsulitis, commonly referred to as 'frozen shoulder', has an incidence of approximately 2–5%, particularly affecting women aged between 50 and 70 years. Patients with diabetes mellitus are likely to present at a younger age, and are five times more likely to have this condition compared to the general population (Redler and Dennis, 2019).

The history presented by the patient will demonstrate gradual onset, with pain preceding any loss in range of movement. The type and severity of pain, as well as limited range of movement, will depend on the stage of the disease. Commonly, three stages have been described: freezing, frozen and thawing. The freezing stage, lasting 3–9 months, is characterised by a reduction in passive and active range of movement, with an increase in pain from acute synovitis of the glenohumeral joint. In the frozen stage, pain remains generally stable, with significant limitation in all movement and atrophy of muscles from immobility. This can last from 4 to 12 months and affects external rotation in particular. In the final thawing stage, range of motion improves over a period of 24 months (Patel et al, 2020).

On examination, it is important to assess for evidence of previous surgery and to compare both shoulders. Findings will be dictated by the stage of the condition, in terms of pain and range of movement, although the latter would be expected to show a global reduction or loss of active and passive range of movement (Limb, 2014).

Plain X-rays should be considered in the first instance to rule out other causes of reduced range of movement, such as glenohumeral arthritis. Ultrasound can be helpful in the freezing stage, where synovitis may be evident. Additional sonographic signs are

Figure 7. Antero-posterior X-ray of the right shoulder demonstrates calcific opacities adjacent to the greater tuberosity of the right humerus, in keeping with calcific tendonitis of the supraspinatus tendon.

non-specific, but may be suggestive, including limited movement of the supraspinatus tendon, thickening of the coracohumeral ligament and inferior glenohumeral capsule (Michelin et al, 2013).

Alternatively, magnetic resonance imaging or magnetic resonance arthrography may be used. Findings are mostly non-specific and include high T2 signal of the inferior glenohumeral ligament, thickening of the coracohumeral ligament, thickening of the joint capsule, and pericapsular scarring in more chronic cases. One of the most specific signs on magnetic resonance imaging is the sub-coracoid triangle sign, which refers to loss of the fat triangle between the coracoid process, glenohumeral joint capsule, and coracohumeral ligament superiorly (Figure 8) (Mengiardi et al, 2004).

Given the self-limiting nature of adhesive capsulitis, treatment is predominantly non-operative, with the stage affecting the choice of treatment (Rangan et al, 2020). Initial options include physiotherapy, oral anti-inflammatory drugs, as well as intra-articular steroid injections. Another non-operative treatment is hydrodistension, which involves injecting the glenohumeral joint with a mixture of saline, local anaesthesia and corticosteroid. The most recent meta-analysis suggests that hydrodistension with corticosteroids is the most effective management of this condition when compared to isolated corticosteroid and physiotherapy alone (Lädermann et al, 2021). When non-operative treatments fail to improve symptoms over 9–12 months, then surgical options, including manipulation under anaesthesia and arthroscopic capsular release, may be required.

Arthritis

A history of any patient with arthritis in their shoulder should ascertain the presence of shoulder pain, whether it is associated with activities, affects sleeping and whether it is present at rest. Patients may also report a loss of range of movement secondary to capsular contraction. Important differential diagnoses when a significant reduction of movement is present include a dislocation and adhesive capsulitis (Ibounig et al, 2021).

Figure 8. Axial imaging shows loss of the fat triangle between the coracoid process, glenohumeral joint capsule and coraco-humeral ligament, in keeping with adhesive capsulitis.

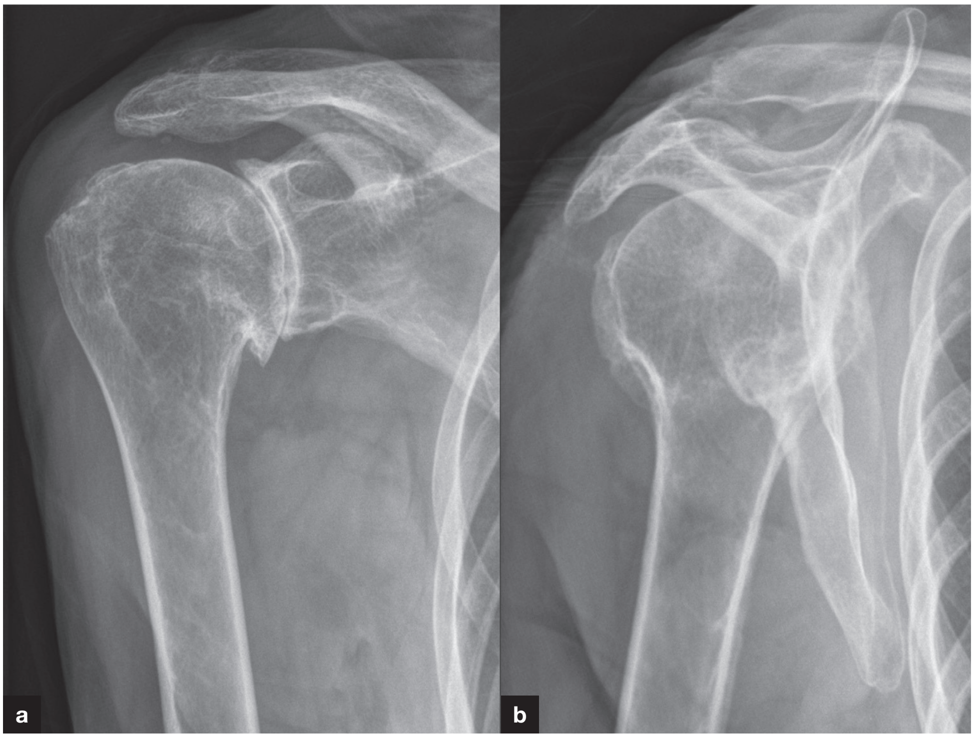

Figure 9. a. Antero-posterior and (b) lateral X-rays of the right shoulder demonstrate osteoarthritic changes, as evidenced by loss of joint space, subchondral sclerosis, subchondral cysts and osteophyte formation.

Osteoarthritis

Osteoarthritis can be primary or secondary to other pathologies. Primary osteoarthritis refers to progressive degenerative change leading to pain and immobility, where risk increases with age. However, the glenohumeral joint is a relatively uncommon site for primary osteoarthritis, accounting for 5–17% of shoulder complaints, with prevalence estimated between 16–20% (Ibounig et al, 2021).

Radiographic signs are similar to those of osteoarthritis in other joints, characterised by loss of joint space, subchondral sclerosis, subchondral cysts and osteophyte formation (Figure 9). Osteoarthritis can be primary or secondary to aetiologies causing joint damage, such as trauma (fractures and dislocations). Ultrasound-guided injection of corticosteroids and hyaluronic acid also play a role in symptom management. Cross-sectional imaging with computed tomography may be considered to evaluate the underlying bony architecture for planning before surgical intervention (Ibounig et al, 2021).

Rheumatoid arthritis

Rheumatoid arthritis is a chronic inflammatory multi-system disease with a prevalence of 0.5–1% (Sommer et al, 2005). Characteristic radiographic changes include marginal erosions, soft tissue swelling, osteoporosis and joint-space narrowing, although magnetic resonance imaging and ultrasound are more sensitive than X-rays for early rheumatological changes, which tend to be non-osseous in nature (Sommer et al, 2005).

Ultrasound can demonstrate synovial hypertrophy and increased vascularity suggestive of active synovitis. Ultrasound and magnetic resonance imaging are also more sensitive when detecting bony erosions (Amin et al, 2012) and should, therefore, be considered as a supplement to diagnosis when X-rays appear normal. Magnetic resonance imaging appearances include synovial hyperplasia (evidenced by the presence of rice bodies), thinning of the articular cartilage, subchondral cysts and bony erosions, as well as joint effusions and bone marrow oedema.

Treatment for shoulder arthritis is based on non-operative management, followed by surgical intervention. A decision regarding treatment depends on patient and disease factors, including severity of presentation or pathology, success of non-operative treatments, the

Key points

- Shoulder pain is a very common cause of musculoskeletal presentations in both primary and secondary care.
- Clinical history and examination are vital to guide the imaging modality of choice to answer the clinical question.
- Imaging can guide diagnosis, surveillance and management of patients with shoulder pain.
- Imaging modalities such as X-rays, ultrasound and magnetic resonance imaging each have their own strengths and weaknesses, and an awareness of these will aid the investigation of choice to facilitate clinical decision making.

presence of concomitant shoulder pathology (eg rotator cuff tears), patient choice and functionality. Non-operative treatment includes analgesia, disease-modifying drugs for rheumatoid arthritis, physiotherapy and injections (steroids and nerve blocks). Surgical treatments include arthroscopic debridements and arthroplasty (eg hemiarthroplasty, total shoulder and reverse shoulder replacements) (Thomas et al, 2016).

Conclusions

This article reviews the common causes of acute and chronic shoulder pain and the available imaging and treatment options that junior clinicians, in particular, should be aware of. It is hoped that the examination and imaging findings described will increase the accuracy of diagnosis and early effective management, limiting patient disability.

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Conflicts of interest

The authors declare that there are no conflicts of interest.

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