



Coracoid stress fracture in an elite fast bowler: description of a technique for CT-guided percutaneous screw fixation of coracoid fractures

Graeme Thompson¹ · Andrew Van Den Heever²

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Abstract

Coracoid stress fractures are a rare sports injury but present a management challenge, with the focus on optimising return-to-play, whilst minimising complications. Potential contributing mechanisms for the injury are briefly discussed and a novel approach to accurate fracture fixation under CT guidance is described. The ability of radiologists to orient themselves in 3D with a volume dataset on a workstation provides an image-guided option for percutaneous fixation that minimises risk of complications.

Introduction

Isolated coracoid fractures are an uncommon injury, accounting for only 1% of all fractures [1], usually arising in contact sports, such as American football or rugby, as a consequence of direct trauma. Stress fractures of the coracoid in sport are a rare subgroup, with only 6 counted over a 47-year period up until April 2017 in a literature review by Knapik et al. [2]. The recurrence of such a fracture in a professional athlete presents a challenge with regard to optimising the operative technique, thus ensuring a timely return to play. The case of an elite fast bowler with a recurrent coracoid stress fracture and the subsequent percutaneous fixation technique under CT guidance is described.

Case description

An elite fast bowler presented initially with anterior shoulder pain while bowling and an MRI demonstrated bone marrow oedema and an incomplete fracture line at the base of the coracoid process (Fig. 1) in keeping with a stress fracture. He was prescribed a period of rest and rehabilitation and sequential

follow-up MRIs showed progressive improvement, with the final study after 9 months showing no significant residual oedema or fracture line (Fig. 2). He returned to play and experienced some discomfort in a warm-up match, following which, in the first international test match, he experienced a “pop” while bowling and severe anterior shoulder pain. He was withdrawn from competition and an MRI (Fig. 3) demonstrated a recurrent and now complete fracture through the base of the coracoid process and adjacent superior glenoid/ scapular border, but not involving the articular surface or labrum. Internal fixation was planned and a musculoskeletal radiologist was approached for assistance with image guidance.

Anatomy

The coracoid varies significantly in length and shape (Fig. 4), but is typically angulated with an inferior pillar projecting anteromedially from the origin on the glenoid and a superior pillar that extends anterolaterally in a more horizontal plane, with an average angle between them of about 85° [4]. Although the coracoid tip is an easily palpated landmark, the fixation screw is not placed through the tip, but through the cortex at the junction with the inferior pillar in line with the coracoid base. The challenge to the orthopaedic surgeon is that this point is not palpated owing to the overlying conjoined tendon. Guidance is usually achieved in theatre utilising single or biplane fluoroscopy [5], but these are still restricted to individual 2D projections and detecting inadvertent cortical transgression is challenging. For a professional athlete in particular, failed union or soft-tissue injury due to malpositioning of the screw would have significant personal and financial consequences.

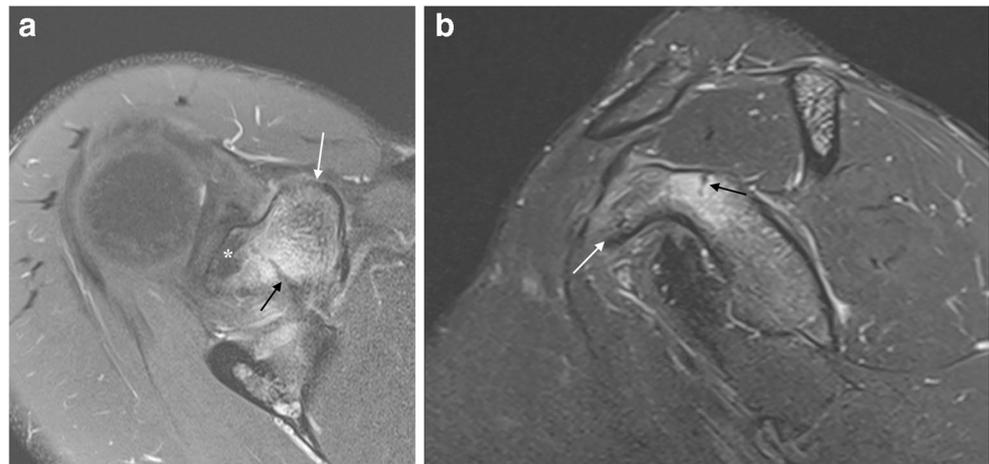
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✉ Graeme Thompson
graemevthompson@gmail.com

¹ Oxford Musculoskeletal Radiology, Oxford, UK

² Cape Radiology, Cape Town, South Africa

Fig. 1 **a** Axial T2-weighted fat-saturated and **b** sagittal short tau inversion recovery images show the fracture line (*black arrows*) at the base of the coracoid process (*white arrows*). The glenoid process is indicated by an *asterisk* in **a**)



Materials and methods

The patient was anaesthetised in the CT department with the surgical team in attendance. He was scanned in the supine position with the arm by the side. The fracture through the coracoid base and adjacent superior glenoid was confirmed and was not displaced (Fig. 5). Axial and sagittal oblique planes were

reconstructed on a workstation, through the optimal long axis of the inferior coracoid pillar, and the planned course of the wire drawn through the centre of the coracoid medulla on both (Fig. 6). This passed through the anterior cortex at the junction of the superior and inferior coracoid pillars, into the glenoid cancellous bone, transfixing the fracture. The resultant angles to the skin surface in the supero-inferior and medio-lateral

Fig. 2 **a** Axial T2-weighted fat-saturated and **b** sagittal T2-weighted fat-saturated images at 9 months showing resolution of oedema and the fracture line (*black arrow*)

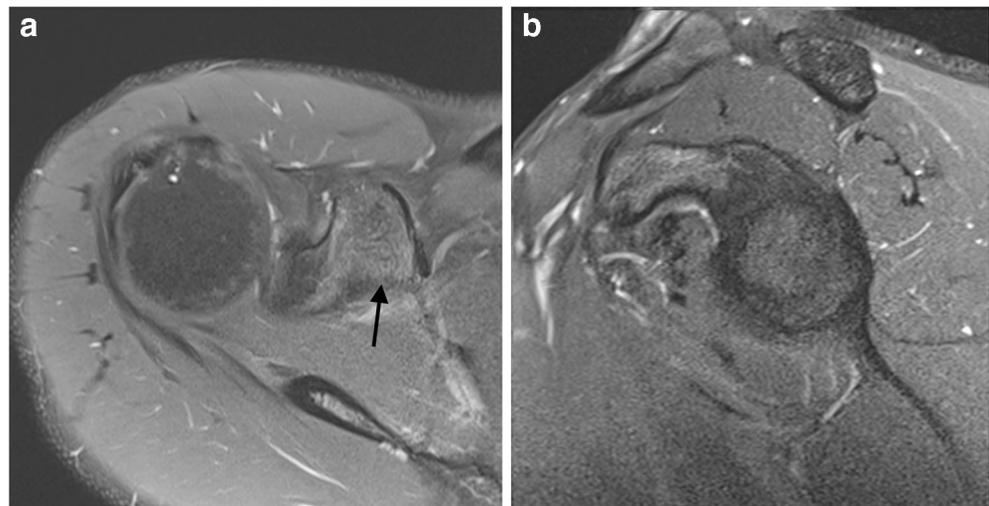
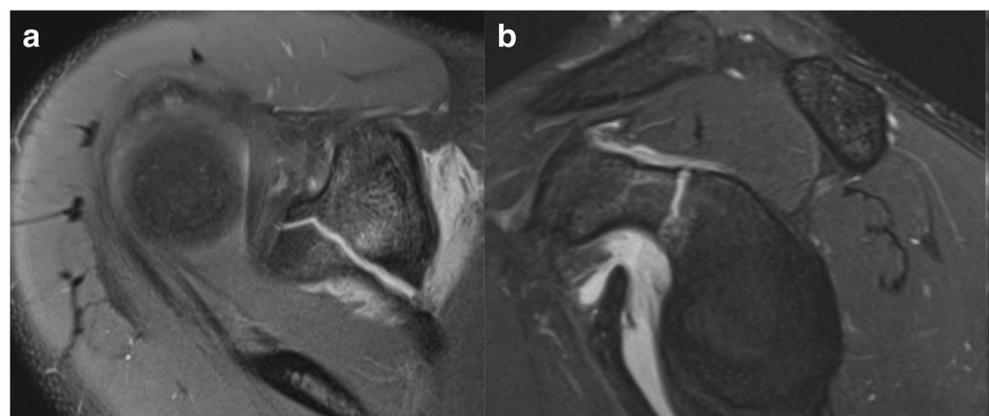


Fig. 3 **a** Axial and **b** sagittal T2-weighted fat-saturated images at the time of the recurrent fracture while bowling (images courtesy of Envision Medical imaging in Perth, Australia)



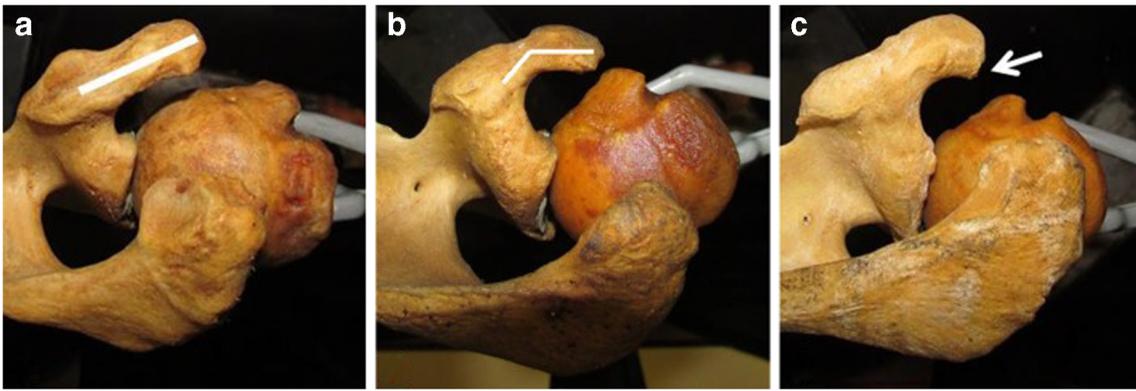


Fig. 4 Variation in coracoid shape from straight **a**, to angulated **b**, to a small anterior osteophyte **c** (white arrow, facing the humeral head). Used under common licence: Dugarte et al. [3]

planes were noted. The skin entry site, just below the clavicle and superomedial to the coracoid, was taken from the intersection of the fixation line on the sagittal oblique with the skin surface. This point was marked on the sagittal oblique and the axial plane was rotated back to orthogonal and placed at the level of this mark. The resultant orthogonal axial image included the tip of the acromion and the distance from the puncture site to the acromial tip was measured (Fig. 7), allowing reproduction of the same point at CT fluoroscopy, which was marked for K-wire placement using a radiopaque grid. A point was then selected 5 mm lateral to this for introduction of a guide needle (25G spinal). This needle was introduced freehand under CT fluoroscopy with a straight gantry, utilising the same angles on the skin as planned on the workstation for the K-wire (Fig. 8). This allowed manipulation into the appropriate alignment with minimal soft-tissue trauma. In this case, the needle passed through the rotator interval and secure fixation required placement of the tip in the glenohumeral joint (Fig. 9), away from the labrum and cartilage, but could be stopped more proximally (with a shorter needle) in patients with unfavourable angles. Enough needle was left protruding from the skin to allow accurate reproduction when introducing the wire. The surgeon

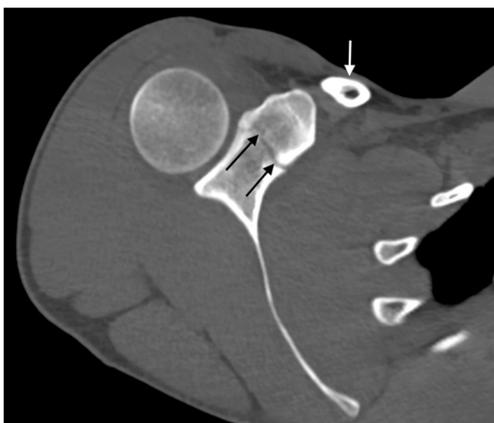


Fig. 5 Axial oblique CT reconstruction showing the fracture (black arrows) through the base of the coracoid and adjacent scapula. Clavicle (white arrow)

then made a small skin incision at the skin mark and introduced the K-wire along the appropriate axis. Sequential CT fluoroscopy sections were performed with small table increments, progressing from the coracoid entry point. A single withdrawal and re-orientation was required early-on owing to projected malalignment, which could be observed by comparison with the marker needle, but the K-wire was then successfully passed through the fracture into the medullary bone of the glenoid process without a distal cortical breach. A cannulated screw was then introduced over the wire and internal fixation achieved (Video 1). At the 6-week follow-up, the patient was pain free, with osseous union of the fracture (Fig. 10).

Discussion

The coracoid process is an important surgical landmark and serves as the attachment site for the coracobrachialis, short head of the biceps and pectoralis minor tendons in addition to the coracoclavicular, coracohumeral and coracoacromial ligaments, earning it the name “lighthouse of the shoulder” [6]. Isolated coracoid fractures are rare, most occurring together with acromioclavicular joint injuries, but may be underreported because of poor pickup rates on conventional radiographic views, particularly as most are undisplaced [6]. The optimal view is an axillary projection, but a high index of suspicion and referral for CT is often required. The consequence of missing the diagnosis may be ongoing pain due to malunion, or impingement on subscapularis by a displaced coracoid. The mechanism of injury in these fractures is not clear, but the possibilities include avulsion as a result of traction by the conjoint tendon and pectoralis minor, and direct trauma from close contact with the humeral head. Coracobrachialis and pectoralis minor, both of which attach to the coracoid, are employed in the adduction and protraction of the scapula that accompanies the follow-through action of throwing [7]. This forceful contraction may

Fig. 6 **a** Axial and **b** sagittal oblique CT reconstructions with projected fixation plane (green line) and its angle to the horizontal (solid white line). The green lines also represent the orientation of the sagittal and axial oblique planes respectively. Skin entry point (red asterisk in **b**). Inferior coracoid pillar (white arrowhead). Superior pillar (black arrowhead)

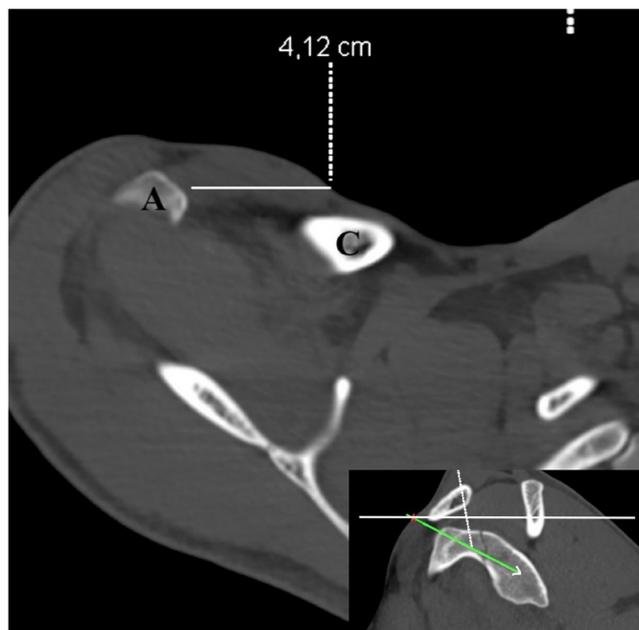
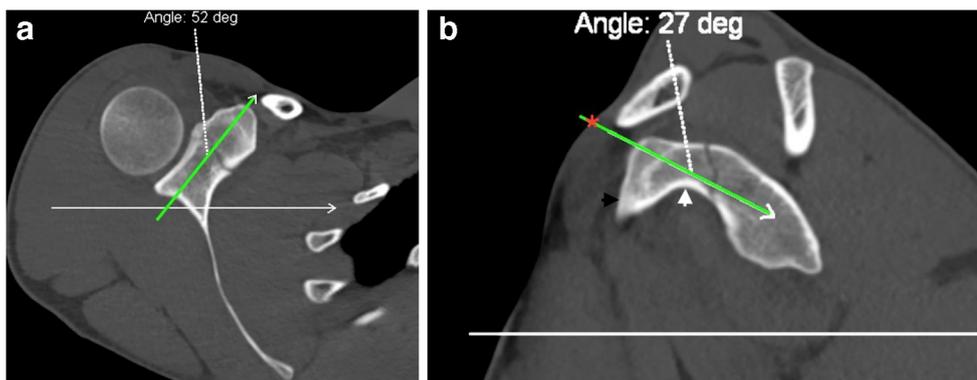


Fig. 7 Orthogonal axial CT section with extrapolated skin entry point inferomedial to the clavicle (C), measured medial to the tip of the acromion (A). Inset shows orthogonal axial plane through the marked skin entry on a sagittal oblique image (white line)

lead to a stress fracture, which would be expected to involve the distal coracoid tip, similar to acute avulsion fractures.

The adduction and internal rotation of the follow-through action also brings the humeral head in close proximity to the coracoid base, producing the second, direct mechanism. Subcoracoid impingement is known to occur during the follow-through phase of overhead throwing, when the arm is in forward flexion, horizontal adduction and internal rotation [8]. This athlete has a prominent, elongated coracoid process with a coracoid index of 16 mm (Fig. 11), normal being less than 8 mm [8]. In an average season, a first-class test bowler bowls up to 200 deliveries per week, with considerable force transmitted through the shoulder girdle. Bowlers with shoulder pain have also been shown to have altered scapular dynamics with downward scapular rotation [9].

The Eyres classification [10] divides coracoid fractures into types 1–5, with type 4 involving the base of the coracoid and a portion of the scapula (Fig. 12). Ogawa et al. [1] classify the fractures as type 1 and 2, in relation to the coracoclavicular ligament attachment (Fig. 13). Surgery has been proposed for Eyres type 4 and 5 injuries, which involve both the coracoid base and the scapula or glenoid [5]. Chammaa et al. [7] described late instability in a cricketer with a similar type 4 stress

Fig. 8 Sequential axial CT fluoroscopy sections demonstrating the 25G calibration needle (black arrow in **a**), 5 mm lateral to the K-wire (white arrow in **a**), which passes in the same plane through the coracoid cortex (white arrow in **b**). Double headed arrow shows 5mm separation of 25G guide and K-wire

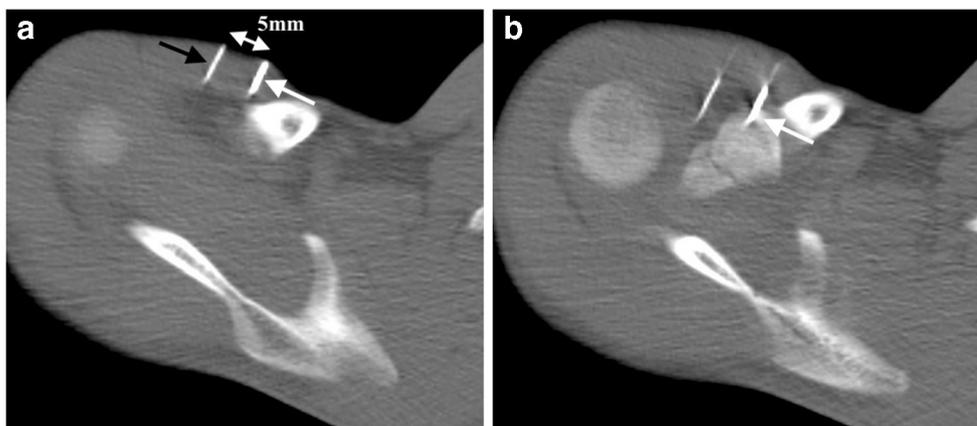


Fig. 9 Axial CT fluoroscopy images showing the 25G calibration needle in the glenohumeral joint space (*black arrow in a*) and the coracoid fracture involving the superior scapular border (*asterisk in a*). The K-wire is shown transfixing the fracture with its distal point in the scapular cancellous bone (*white arrow in b*)

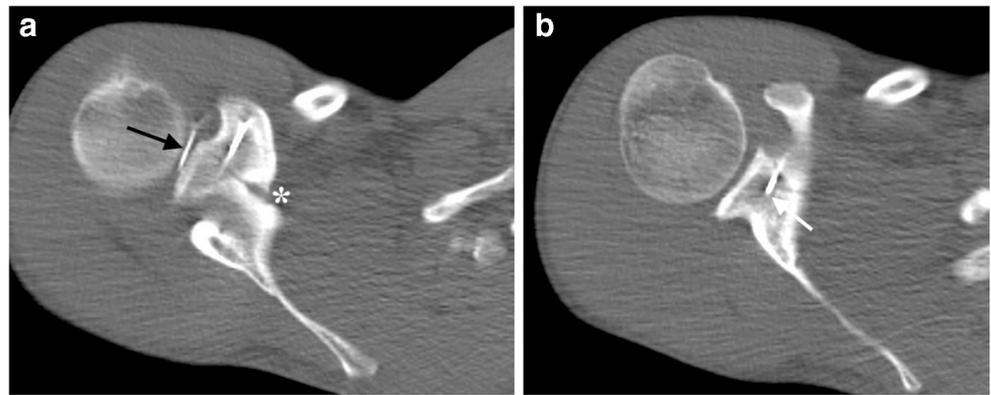


Fig. 10 Anteroposterior and lateral radiographs at 6 weeks



fracture and emphasised the need to exclude concomitant labral injury, which was not present in our case. Although their review described little difference in return to play for operative

and non-operative groups in sports-related coracoid fractures, Knapik et al. found a 19% incidence of complications in the conservative group [2]. These complications include delayed and non-union, both undesirable for a professional sportsperson, prompting surgery in selected cases. However, the onus is on the surgical team to minimise the risk of operative complications.

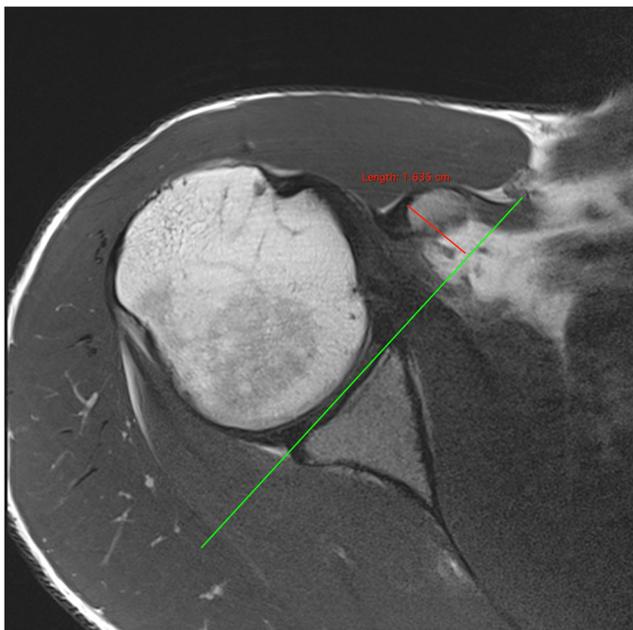


Fig. 11 Coracoid index: the lateral projection of the coracoid tip beyond the tangent to the glenoid surface (*green line*). The measurement in this case was 16 mm

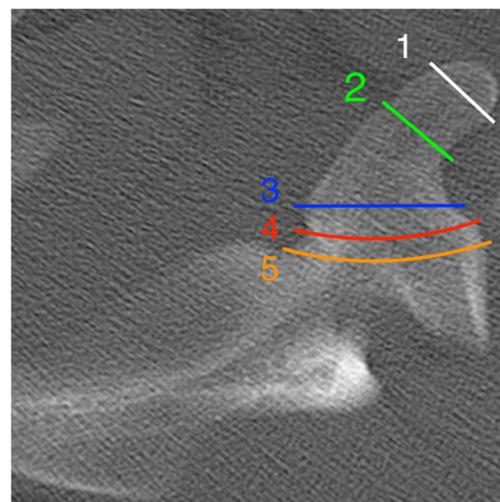


Fig. 12 The Eyres classification of coracoid fractures (1–5)

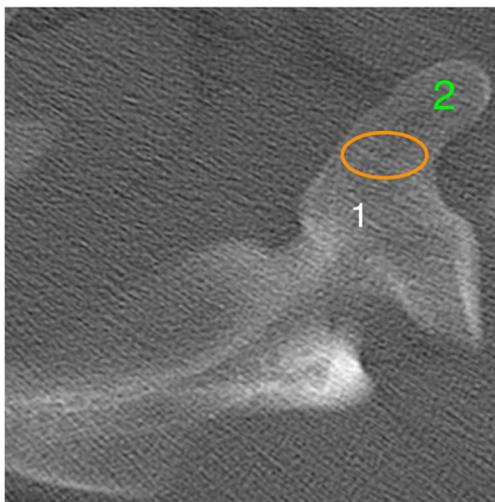


Fig. 13 The Ogawa classification of coracoid fractures. Coracoclavicular ligament attachment shown (*orange oval*)

This report has described a method of CT guidance that allows constant supervision of the needle tip, while also preventing excessive soft-tissue trauma from multiple cannulations by K-wire. The use of a guidance needle is preceded by the trocar technique of abdominal and pelvic abscesses [11]. It would of course be optimal to place the K-wire ab-initio into the coracoid in-plane, under direct CT guidance with no second puncture. However, this would require angling the gantry into a position that would make the operative site inaccessible. In addition, the access angle may be in excess of the permitted gantry tilt. Even if this were not the case, it is likely that without the optimal angle exhibited by the adjacent spinal needle, repeated cannulations may be unavoidable, considering the coracoid anatomy.

As this technique is described in a single patient, limitations may apply. The technique is dependent on an anaesthetised and thus motionless subject and could be of limited use when used with local anaesthetic or conscious sedation in restless patients. Anatomical variation may also create difficulty in choosing an approach, but the careful assessment of the planning study should be effective in most cases. The reference needle in our case passed into the glenohumeral joint space without transgressing the labrum, allowing deep insertion, but care would have to be taken in alternate orientations to avoid injuring labrum, cartilage and tendon, perhaps requiring a shorter needle with more superficial placement, sufficient to hold orientation. The radiation dose from the procedure was 0.5 mSv. For improved sterility provided by a theatre environment, an O-arm could be used in place of CT.

It is the authors' hope that this report will help to provide a method of ensuring operative success in a high-stakes environment.

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Compliance with ethical standards

Consent was obtained from the patient to publish this article.

Conflicts of interest The authors declare that there are no actual or potential conflicts of interest in relation to this article.

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