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Scapula fractures: a review

David Limb

- A consensus is beginning to emerge about the indications for fixation of fractures involving the glenoid fossa of the scapula. The same cannot be firmly said for extra-articular fractures of the blade or the processes of the scapula, with a good deal of reliance on expert opinion from high-volume centres. There are no randomized controlled studies and the systematic reviews that do exist can only pool the data from available case series, making meaningful meta-analysis of limited value. Interest in scapula fractures has increased of late due to the specific association of fractures of the scapular spine and acromion with reverse shoulder arthroplasty.
- This review summarizes the available evidence that can assist decision making when faced with a patient with a scapula fracture. Which patients should at least be considered for open reduction and internal fixation, either in the centre where they present or after referral to a more specialist centre? These patients are those with a fracture sufficiently displaced that it interferes with the mechanical function of the shoulder girdle and the aim of fixation is to reduce pain and disability.
- Since the majority of scapula fractures heal quickly with non-surgical treatment and do not cause significant disability, decision making can be difficult, and it is perhaps the case that it is easier to err on the side of caution.
- However, it seems that there are fracture types, such as significantly displaced double disruptions of the superior suspensory complex, widely displaced lateral column fractures and fractures producing angular deformity of the glenoid process, that benefit from early reduction and stabilization with the expectation of a good outcome for the patient.

Keywords: fracture; reverse shoulder arthroplasty; scapula

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Introduction

Reviews of the early history of scapula fractures pay tribute to pioneering French surgeons, but the first study devoted entirely to scapula fractures was that by Traugott Karl August Vogt in 1799.[1,2] It was not until 1939 that the first publication concerning the internal fixation of a scapula fracture with operative radiographs appears, though unsurprisingly Lambotte had described the fixation of a scapula fracture in his book on the operative management of fractures in 1913.

However, the biological and mechanical environment of the scapula is rather unique and this has an impact on the tendency of fractures to displace (or rather, in many cases, not to displace) and on the stability of most fractures, even in the first days after injury. The blade of the scapula is encased by the fibromuscular envelope of the rotator cuff muscles and suspended on the thorax by muscular attachments. Unlike the long bones that are fixed between synovial joints, the scapula is able to dissipate energy applied through the attached upper limb to its rather elastic but active suspension arrangement. Directly applied forces are absorbed, to a degree, through the encasing rotator cuff muscles. Even if sufficient force is applied to overcome these mechanisms, the fracture fragments that result are held within a highly vascular fibromuscular envelope, which both provides early stability and brings a good blood supply so that the risk of nonunion is very low. The vast majority of scapula fractures are therefore minimally displaced and can be managed by early mobilization with the expectation that they will heal and leave remarkably little in the way of dysfunction,[3–5] though the outcome may be somewhat less favourable in polytrauma patients.[6]

The processes of the scapula (glenoid, coracoid and spine/acromion) do not enjoy the same degree of muscular envelopment, but nevertheless do provide attachments for muscles and ligaments that apply opposing and often balanced forces. However, these are more vulnerable to disruption and displacement, as will be described. This article will not, however, concern itself with intra-articular fractures of the glenoid fossa, which have recently been discussed in this journal.[7,8]

The epidemiology of scapula fractures is changing. They have long been thought of as high-energy fractures, which are markers for severe associated injuries.[9] The rate of this particular injury appears to be rising; the USA National Trauma Data Bank demonstrated a doubling (from 1% to 2.2% of all patients entered onto the data bank having a scapular fracture) over a single decade.[10]

However, the increased use of computerized tomography (CT) to assess trauma patients means that more scapula fractures are being identified – a study involving patients undergoing chest imaging for blunt injuries at nine level 1 trauma centres included 11,477 subjects and found scapula fractures in 2.7% of these, 60.3% of which were not visible on chest radiographs and only seen on the CT scan.[11]

Although taken as a marker for severe injury, there is some evidence that the scapular fracture itself may absorb energy that might otherwise have been transmitted to the thoracic contents, such that when patients with scapular fractures are compared with those without, but otherwise equally severe Injury Severity Scores, the scapular fracture patients actually have an approximately 10% lower mortality.[12] In the theatre of war, however, the mechanisms of injury are different to those of civilian life and whilst scapula fractures normally make up less than 1% of all fractures, a 10-year study of military personnel found that scapula fractures made up 7.7% of all upper limb fractures treated.[13]

The dramatic shift in practice related to shoulder arthroplasty in the last three decades, such that reverse geometry is now more common than anatomic designs in most registries, has also ushered in a new variant of the scapula fracture theme. Use of reverse geometry shoulder replacements, with inferior placement of the glenosphere and tensioning of the deltoid, has resulted in the emergence of acromial and scapula spine fractures in patients with reverse arthroplasty. Although some have resulted from trauma and have responded well to internal fixation,[14] it seems that many are stress fractures and the optimal treatment is still debated.

Assessment

The association between scapular fractures and other significant injuries in the context of high-energy trauma has been highlighted, but it is the history of the mechanism of injury that should primarily alert the surgeon, rather than the presence of a scapula fracture per se. Epidemiological studies of scapular fractures in general show that in older patients, females tend to be more affected than males[15,16] and in these, low-energy mechanisms become more prevalent, presumably due to the influence of osteoporosis. For the same reason the pattern of associated injuries changes from thoracic, spinal and chest injuries as seen in young, high-energy groups,[9] to an increased incidence of proximal humerus fractures in the elderly.

In higher-energy accidents the associated injuries can be thought of in terms of their impact on patient management: those that influence resuscitation and initial management, those that are significant and demand early treatment but are remote from the scapula and those that are integral to the fracture pattern of the scapular injury itself and whose management is intimately linked to the scapular injury. While assessment initially focusses on resuscitation, it is important to inspect the skin around the shoulder girdle as open wounds, abrasions and degloving can affect decisions on the risks and timing of surgery. Fractures associated with reverse geometry arthroplasty will be considered separately.

The investigation of scapula fractures has traditionally included an initial chest X-ray and lateral cervical spine radiograph, followed by anteroposterior (AP), axial and scapular lateral views of the shoulder. Nowadays high-energy trauma patients almost universally receive a head/chest/thorax/abdominal/pelvic trauma CT scan, which has greatly facilitated the detection and planning of management for scapular fractures. However, the slice thickness and field used for trauma CT may not be ideal in all cases, and after the resuscitation phase a thin-slice CT will allow detailed examination of the fracture configuration with the options of multiplanar reconstruction and 3D modelling. Although more useful in articular fractures, the latter can be enhanced by subtraction of the humeral head from the reconstructed data, giving full visualization of the glenoid process and its relationships to the coracoid, spine and scapular blade (Fig. 1).

Associated injuries: resuscitation phase

Such injuries include underlying thoracic injury, and it has already been mentioned that although scapular fractures are associated with rib fractures and thoracic injury, the mortality rate is not adversely affected by the presence of a scapula fracture and this may be because the fracture itself absorbs energy that might otherwise have been transmitted to vital structures. It has also been shown

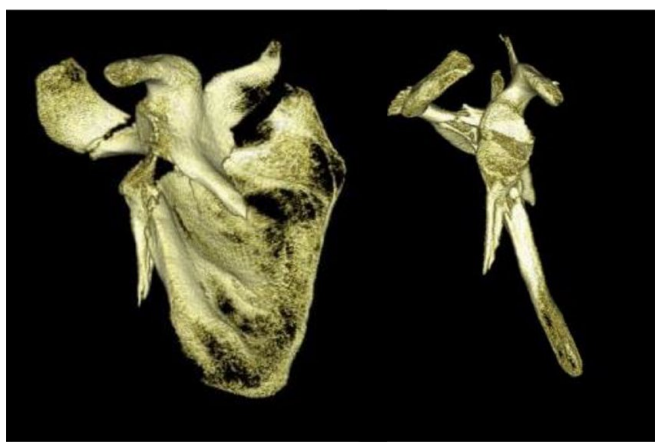

Fig. 1 Three-dimensional reconstruction is useful in assessing the extent of scapula fractures and subtraction of the thorax and humeral head facilitates appreciation of the fracture pattern.

that the presence of a scapula fracture does not adversely affect the outcome of management of the thoracic injury if underlying rib fractures are plated.

In addition to thoracic injury the most significant associations of scapular fractures depend on mechanism. In motor vehicle accidents spinal injuries are frequently associated, as are clavicle and tibial fractures, but also liver and spleen injuries.[12] This may well reflect the influence of the seatbelt on the distribution of dissipated energy. Motorcycle injuries often result in force being applied downwards on the shoulder and become associated with brachial plexus and head injuries,[17] creating a range of diagnostic possibilities for neurological loss and mandating spinal stabilization, head injury precautions and appropriate emergency investigations. Bear in mind, in all cases with neurological loss, the possibility of scapulothoracic dissociation with its attendant risk of vascular injury. This would not normally include a scapular fracture, but can be detected by looking for asymmetric separation of the medial border of the scapula from the midline on CT or chest X-ray.

Associated injuries: early management phase

Clearly the early management phase will include definitive management of significant chest, head, spine, brachial plexus, abdominal, pelvic or long bone injury picked up during resuscitation. Clavicle fractures are frequently associated with scapular fractures, and if the scapula fracture is minimally displaced then the clavicle fracture can be treated on its own merits.

Superior suspensory complex injuries

Of particular relevance to management decisions for scapular fractures are injuries to the superior shoulder suspensory complex. This is the osseoligamentous ring that provides muscle attachments around the articulation of the humeral head with the glenoid fossa and helps maintain a stable, functional link between the upper limb and the axial skeleton. As with the pelvis, double disruptions of the ring can significantly impair function – the so-called 'floating shoulder',[18,19] and care should be taken to detect contributory lesions.

The ring is formed inferiorly by the glenoid neck with its two superiorly projecting processes – anteriorly the coracoid and posteriorly the scapular spine, which leads to the acromion. The acromion articulates with the distal clavicle through the acromioclavicular joint capsule, and the distal clavicle in turn is connected to the coracoid through the conoid and trapezoid ligaments, whilst the coracoacromial ligament directly connects the acromion with the coracoid. Disruption should therefore be sought at the glenoid neck, scapular spine, acromion, coracoid, acromioclavicular joint, distal clavicle and coracoclavicular ligaments, which themselves can also be defunctioned by clavicle shaft fractures. Double disruptions were felt to indicate surgical stabilization of both elements to restore stability – originally fixation of associated glenoid neck and clavicle fractures was recommended.[19,20] Later, evidence began to appear that in the case of clavicle and glenoid neck fractures, plating the clavicle alone provided a simpler and effective option,[21] whilst others advise non-operative management for minimally displaced injuries and surgery for significant displacement.[22] In the absence of accepted criteria for displacement of each element, and of any randomized studies, the area of decision making in floating shoulders is unclear, except to say that such double disruptions do tend to lower the threshold for surgical intervention for at least one, if not both, the injured components.

Classification

The very first classification of scapular fractures, by Jean-Louis Petit[23] identified fractures of the scapula that affected the body, neck and processes; this is a very useful descriptive classification and one therefore sees it at the fundamental level of the much more recent AO/OTA classification.[24] This classifies scapula fractures into extra-articular injuries affecting the processes (14A), the body (14B) (Fig. 2) and intra-articular fractures affecting the glenoid fossa (14F), which are beyond the scope of this review. Detailed classification will be important for research but

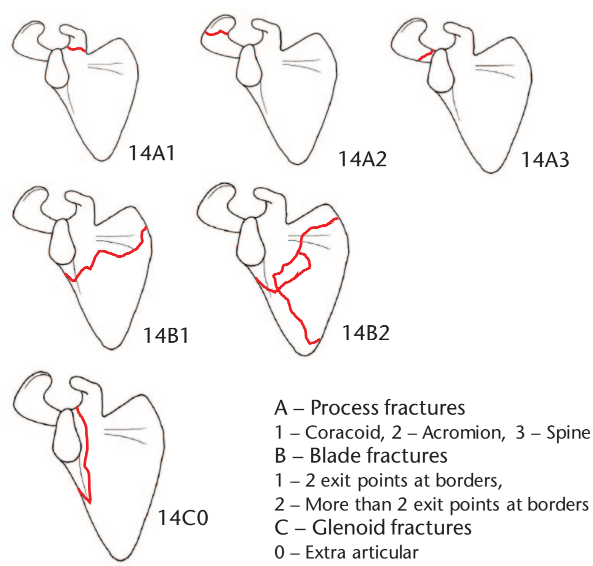

Fig. 2 Extra-articular fractures of the scapula as they are classified in the AO/OTA classification system.

communication is simple if one refers to fractures of the glenoid neck, coracoid and/or acromion and to scapular blade fractures that are simple or complex – the essence of almost all classification systems.

Indications for surgery

When surgery for scapular fractures has been tried, it has given results that are at least as good as non-surgical management and the indications for surgery were initially based on expert opinion only.[25,26] Of course, the potential for selection bias means that, although it is unlikely that operative treatment gives significantly worse results (in which case there would also be articles reporting this finding), it cannot be said that operative treatment is superior. Nevertheless, the stimulus was there to investigate outcomes and move towards stronger scientific evidence. Based on one author's own experience, which happens to be the widest published experience of the operative management of scapular fractures, along with all other published evidence, advice is available on the fracture characteristics that can be used to assess fractures for fixation, and how to perform those measurements.[27] Despite the existence of such criteria, most publications since still lack clarity in terms of the precise indications for surgery.

Commonly cited indications for surgery are medial displacement of the lateral border > 25 mm, angular deformity of > 45°, intra-articular step of 3 or 5 mm and displaced double disruptions of the superior shoulder suspensory complex. More recently the glenopolar angle has been added to the list and shows promise, though a recent systematic review demonstrated that the positive relationship between glenopolar angle and outcome that has been published will need larger studies to prove.[28] It is not unusual to hear medialization of the glenoid mentioned as an indication for surgery, but care should be taken with this concept. Apparent medialization is actually often caused by lateral displacement of the lateral border of the scapula under the influence of the attached teres muscles. When measured from the midline and compared to the opposite shoulder, true medialization of the glenoid is much rarer than was thought.[29]

Further indications can arise in more unique circumstances when displacement affects the function of the scapulothoracic joint rather than the glenohumeral joint. Angular deformity of > 45° is an example of this that has already been discussed, and for the same reason gross chest wall deformity from underlying rib fractures could come into this category and provide an indication for rib fixation. Other more unusual examples include displacement of the angle of the scapula between ribs to become intra-thoracic,[30] and displacement of segments of the blade of the scapula such that they pierce the subscapularis and project into the chest wall creating pain and limitation of movement.[31]

Isolated fractures of the coracoid process or acromion may be seen as an indication for fixation if displaced. The outcomes are reported to be good, but based on case series so no real comment can be made on the relative merits of surgical and non-surgical treatment.[32]

It remains the case that the major indications for scapular fracture fixation relate to the management of intra-articular fractures of the glenohumeral joint, which are not the focus of this review. Conceptually the extra-articular fractures that should benefit from fixation are those which are sufficiently displaced that non-surgical treatment would reasonably be expected to be associated with compromised shoulder function. This should include those with sufficient distortion of the scapular blade that scapulothoracic and/or rotator cuff function will be impaired, and those with displacement that significantly affects the relationship between the glenoid fossa and the blade of the scapula, in turn affecting glenohumeral joint function. Whilst these are broadly covered by the generalized recommendations above, it is still true that each case should be assessed on its own merits and even if the criteria are met, this establishes a relative indication for surgery which needs to be discussed with a surgeon confident in the surgical management of scapular fractures and in the context of the specific patient and injury characteristics.

Surgical approaches

Assuming a decision has been taken to operate, the surgeon then needs to assess the fracture and plan fixation. Although anterior approaches, with the patient in the beach chair position, are employed for the most commonly fixed glenoid fractures, scapula blade fractures demand a posterior approach with the patient in the lateral position. The Judet approach[33] gives wide exposure of the blade of the scapula from the attachment of the spine downwards and including the lower one third to one half of the posterior glenoid. It is very useful when plates are planned for both medial and lateral columns of the scapula, but complete detachment of infraspinatus may be responsible for the commonly reported weakness of external rotation afterwards. However, the latter can also be caused by injury to the suprascapular nerve at the spinoglenoid notch, which is commonly traversed by fracture lines.[34,35]

Consideration has to be given to the bone that is available for fixation, however, and in the scapula that is limited to its borders and processes, as can be seen by simple transillumination of the bone (Fig. 3). Even at the borders the length of screws that can be used is limited – apart from the region of the glenoid itself, a study on the thickness of available bone showed that neither the scapular

Fig. 3 A scapula transilluminated to demonstrate the thicker areas of bone that might be suitable for fixation, which are peripherally distributed.

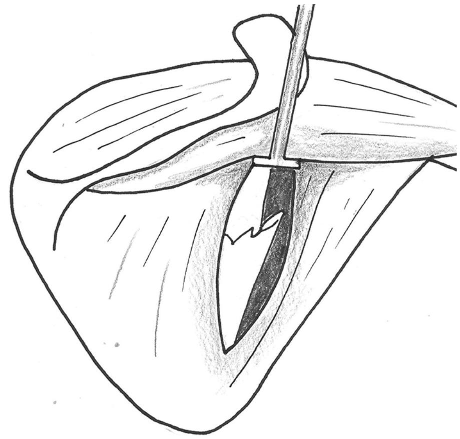

Fig. 4 The most commonly utilized approach for scapular blade fractures, including those with intra-articular extension, exploits the interval between infraspinatus and teres muscles.

spine nor the lateral border, the two thickest regions, on average exceeded the length of the shortest screws on a standard plating kit (8.3 mm and 9.7 mm respectively).[36]

A minimally invasive approach has been described that allows access to both medial and lateral columns, which in any event are often the sites of election for plate application.[36] The lateral of the described incisions exploits the interval between infraspinatus and teres minor, which gives access to the entire lateral column and the same access to the posterior glenoid as the Judet approach (Fig. 4). This is the author's preferred approach and, since the majority of medial blade fractures are relatively undisplaced, at least after fixation of the lateral column, then the medial incision and fixation can be dispensed with.

Reduction of fracture fragments can be difficult, and some tricks can be used to assist. The lateral column is often shortened and if the fracture is more than a few days old shortening of the cuff muscles, exacerbated by the downward force of latissimus dorsi on the arm in abduction, can make powerful distraction necessary. This can be facilitated by inserting small fragment screws in the proximal and distal fragments and using a laminar spreader to bring the fracture out to length and reduce it. A temporary minifragment plate applied away from the proposed definitive plate site allows the small fragment screws to be removed from the good bone of the lateral column to which the definitive plate can be applied. Rotational deformity of the glenoid can also be problematic, especially if it involves the superior part which is not in the operative field. If the coracoid is intact, however, a long percutaneous screw or threaded pin into the coracoid, or an applied clamp through a small anterior incision, gives control over the superior glenoid. The glenoid may also be visualized by image intensifier or by an arthroscope inserted into the joint, from within the posterior operative field if necessary.

After surgery, scapular fractures that have been stabilized heal well and can be mobilized as soon as pain allows, aiming to have all limitations removed by six weeks. However, external rotation weakness is common, particularly after use of the Judet approach but also because of the vulnerability of the suprascapular nerve at the spinoglenoid notch to traction or compression caused by fracture displacement.

Outcomes

One problem with the determination of the place of surgery in the management of scapular fractures is that, in general, the reported outcomes of non-operative treatment are good, at least if the fractures heal with only modest deformity.[37,38] However, the commonest pattern of extra-articular scapula fractures that is fixed is the glenoid neck fracture, and an attempted meta-analysis in 2013 comparing surgical and non-surgical treatment could only conclude that no clear differences could be identified and each case has to be considered on its own merits.[39] This study reported an overall complication rate of 10% in the included articles. Further data have been published since, but only a few more series and it is obvious from reviewing these that they do not contain information that is markedly different from that which has informed earlier meta-analysis. The largest of these comes from the world's most prolific team (in terms of the reporting of scapula fracture management), who report on the long-term outcomes in both surgical and non-surgical groups. They found excellent outcomes in surgically treated patients, with some loss of external rotation compared to the unoperated side, but nevertheless reported the results of non-operative management to be comparable.[40]

It still cannot be said, however, that non-surgical treatment is as good as surgical treatment. Selection bias means that the literature may be reporting on surgery applied to the worst fractures and the most favourable fractures undergoing non-operative treatment. The data available should certainly, however, discourage anyone from 'having a go', but it behoves those who do operate on these injuries to use established measurement criteria for assessment and to report their work in a way that facilitates future meta-analysis, as the frequency of these injuries means any sort of randomized controlled trial is unlikely to recruit sufficient patients.

Scapula spine fractures in reverse shoulder arthroplasty

The dramatic growth in reverse shoulder arthroplasty procedures has drawn attention to an occasional complication, which is encountered by arthroplasty surgeons more often than trauma surgeons, and that is fracture of the scapular spine. This occurs most commonly at the base of the acromion or close to the spinoglenoid junction. It can occur a few weeks or many months after surgery, with a peak at around nine months[41,42] and an incidence of up to 4.3%, depending on the specific prosthesis used.[43] The latter observation may be related to the site of emergence of screws used to fix the glenosphere and the use of shorter screws aimed at the base of the coracoid is recommended for baseplate fixation. Most are atraumatic in origin[44] and associated with low bone mineral density. They are commoner with a history of previous shoulder surgery (including rotator cuff repair), but the evidence on whether deltoid lengthening or shortening is related is contradictory and may reflect the multifactorial nature of the problem.[42,45] Acromial stress reactions have been described, with tenderness at the base of the acromion or adjacent scapular spine and pain in the absence of radiological features of fracture. These occur with a peak at 7.3 months after implantation.[46] The outcomes of arthroplasty are inferior in those patients who suffer a fracture, particularly in those with attempted non-operative management in an abduction brace. A recent systematic review found them to be reported most commonly after arthroplasty for inflammatory arthritis (10.8%) and lowest for post-traumatic arthritis (2.1%) and acute fracture (0%). Lateralized glenospheres were associated with more fractures than medialized, and the overall rate was 2.8%.[46]

Treatment of scapular spine and acromial fractures after reverse shoulder arthroplasty is challenging, as the outcome of various treatment types is unpredictable. Non-operative treatment, with rest and an abduction pillow for around six weeks until symptoms subside, is recommended if symptoms of a stress reaction develop. This can prevent progression to a fracture, as the latter negatively impacts the outcome of the arthroplasty. Non-surgical treatment is widely recommended for fractures affecting the acromion and the segment of spine suspending the acromion (classified as type I and II fractures by Levy[47] as fixation is difficult and prone to failure – see Fig. 5). Surgical fixation is used for displaced fractures, and plate fixation seems to be more successful that tension band wiring.[48] Certainly, if fixation is to be employed it is better to act before significant displacement occurs. Because of the frequency of osteoporosis, and the paucity of bone available for secure plate fixation, however, it may be necessary to develop patient-specific methods such as lag screw fixation of a split fibula graft through the scapula spine, sandwiching the fracture (Fig. 6).

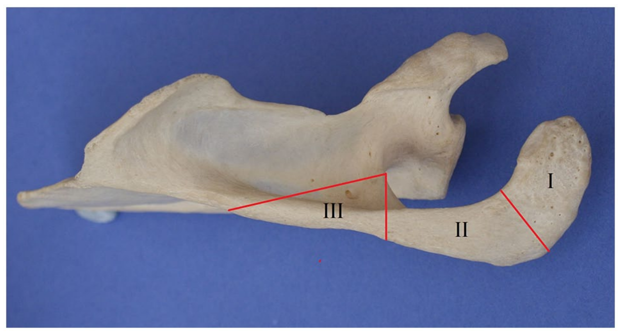

Fig. 5 Levy classification[46] of scapula spine fractures associated with reverse shoulder arthroplasty.

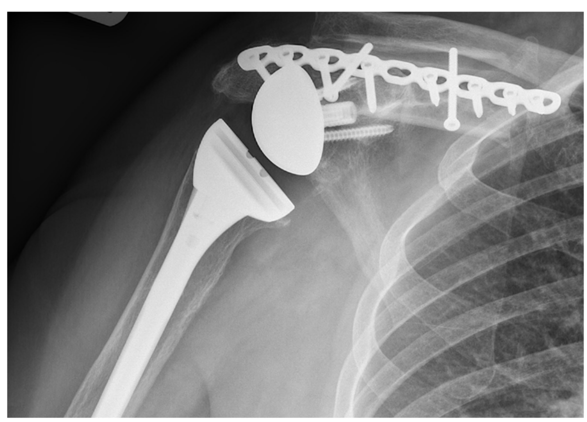

Fig. 6 A scapular spine nonunion following fracture after reverse shoulder arthroplasty, treated in this case by lag screw fixation of a split fibula graft either side of the spine.

Conclusion

Fractures of the scapula may be associated with high-energy mechanisms in the young, with significant associated injuries to the thorax, spine, head and abdomen. They also occur in the elderly from low-energy mechanisms, and the commonest associated injury with this group is the proximal humerus fracture. Injuries that compromise the function of the glenohumeral or scapulothoracic joints can be considered for fixation. Surgery has outcomes that are at least as good as non-surgical treatments, indications commonly being considered as displacement of the lateral column by at least 25 mm, angular deformity of at least 45°, intra-articular steps of 3–5 mm or double disruptions of the superior suspensory complex. Unfortunately, even meta-analysis of available data does not clearly show an advantage for surgery and the true indications are still to be defined. Fracture of the scapular spine is increasing in frequency because of its association with reverse shoulder arthroplasty. The outcomes of the arthroplasty are worse if fracture occurs, so acromial stress reactions, if detected, should be managed with rest and rehabilitation, but displaced fractures are often managed surgically. Not all are amenable, however, and the risk of complications including non-union is significant, so this is another area where the indications for surgery and the most successful techniques are still to be defined.

AUTHOR INFORMATION
Leeds Teaching Hospitals NHS Trust, Leeds, UK.

Correspondence should be sent to: David Limb, Dept of Orthopaedic Surgery, Chapel Allerton Hospital, Harehills Lane, Leeds, LS7 4SA, UK.
Email: d.limb@leeds.ac.uk

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