■ ASPECTS OF CURRENT MANAGEMENT

Injuries to the acromioclavicular joint

J. A. Fraser-Moodie,
N. L. Shortt,
C. M. Robinson

*From the Royal
Infirmary of
Edinburgh,
Edinburgh, Scotland*

Injuries to the acromioclavicular joint are common but underdiagnosed. Sprains and minor subluxations are best managed conservatively, but there is debate concerning the treatment of complete dislocations and the more complex combined injuries in which other elements of the shoulder girdle are damaged. Confusion has been caused by existing systems for classification of these injuries, the plethora of available operative techniques and the lack of well-designed clinical trials comparing alternative methods of management. Recent advances in arthroscopic surgery have produced an even greater variety of surgical options for which, as yet, there are no objective data on outcome of high quality. We review the current concepts of the treatment of these injuries.

Anatomy and biomechanics

The acromioclavicular joint provides a 'key-stone' link between the scapula and the clavicle. The coupling of scapulothoracic and glenohumeral movement dictates that the integrity of the sternoclavicular and acromioclavicular joints is important for the normal co-ordination of movement of the shoulder girdle. Until recently, movement at the acromioclavicular joint had not been accurately defined and was perhaps underestimated.¹⁻³ It is now appreciated that during abduction of the shoulder, there is 15° of protraction, 21° of upward rotation and 22° of posterior tilting of the scapula relative to the clavicle at the joint.³

The acromioclavicular joint is surrounded by a thin fibrous capsule which is reinforced by the superior, inferior, anterior and posterior acromioclavicular ligaments. The superior and posterior components provide the most significant contribution to horizontal stability at the joint. The acromioclavicular joint is further strengthened by the deltotracheus aponeurosis. The coracoclavicular ligament consists of the conoid and trapezoid components which stabilise the acromioclavicular articulation⁴ and co-ordinate scapulothoracic rotation during abduction and flexion of the shoulder.

Several studies have attempted to establish the complementary roles of the ligaments when the joint is subjected to non-physiological forces. Urist⁵ suggested that control of horizontal and vertical stability was provided by the acromioclavicular and coracoclavicular

ligaments, respectively. Later studies suggested that at physiological loads the acromioclavicular ligaments prevent displacement,⁶ while if pathological forces are applied, the coracoclavicular complex prevents subluxation by controlling vertical movement. However, the respective functions of the conoid and trapezoid components remain unclear.⁶⁻⁸

The displacement of the bone ends which occurs after acromioclavicular dislocation is caused by sagging of the shoulder girdle rather than by superior displacement of the clavicle.⁴ The most common cause of acromioclavicular injury is a force applied directly over the superolateral border of the shoulder usually during a fall with the humerus adducted. This force drives the clavicle and acromion inferiorly, but the strong interlocking ligaments at the sternoclavicular joint limit the amount of inferior displacement of the clavicle⁹ and the greater degree of inferior transposition of the acromion ruptures the acromioclavicular and coracoclavicular ligaments.

Epidemiology

Injuries to the acromioclavicular joint account for approximately 12% of those to the shoulder girdle seen in clinical practice.¹⁰ This is likely to be an underestimate of their true prevalence, since patients with minor sprains may not seek medical attention. They are between five and ten times more common in males. Incomplete separations of the joint are approximately twice as common as complete disruption

■ J. A. Fraser-Moodie,
MRCSEd, Clinical Research
Fellow
■ N. L. Shortt, FRCSEd(Orth),
Orthopaedic Registrar
■ C. M. Robinson, BMedSci,
FRCSEd(Orth), Consultant
Orthopaedic Surgeon
Edinburgh Shoulder Clinic
The Royal Infirmary of
Edinburgh, Old Dalkeith Road,
Edinburgh EH16 4SU, UK.

Correspondence should be sent
to Mr C. M. Robinson; e-mail:
c.mike.robinson@ed.ac.uk

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Fig. 1a

Fig. 1b

Fig. 1c

Fig. 1d

Fig. 1e

Fig. 1f

Diagrams showing injuries of the acromioclavicular joint a) type I, b) type II, c) type III, d) type IV, e) type V and f) type VI.

tions.² In a review of 520 of these injuries, more than 300 occurred in the first three decades of life and most were minor sprains and subluxations.²

These injuries are typically sustained by younger patients participating in contact sports. They are the most common injury to the shoulder seen in American football players,¹¹ and in other developed countries are usually sustained in sports such as rugby, soccer and Australian rules football.¹² Among recreational skiers approximately one-fifth of injuries to the shoulder girdle involve the acromioclavicular joint.¹³

Classification

Isolated injuries of the acromioclavicular joint. Tossy, Mead and Sigmond¹⁴ described three types of acromioclavicular dislocation, to which Rockwood et al² added a further three subgroups. The classification is based on the extent of disruption of the acromioclavicular and coracoclavicular ligaments using the radiological degree of displacement of the clavicle relative to the acromion.

In type-I injuries (Fig. 1a) there is partial and in type II (Fig. 1b) complete disruption of the acromioclavicular ligaments. In both, the radiographs will appear to be normal. The severity of the injury then progresses with complete disruption of the acromioclavicular and coracoclavicular ligaments. In type-III injuries (Fig. 1c), the vertical translation at the joint is up to the width of the clavicle while in type IV (Fig. 1d) the clavicle is displaced posteriorly into or

through the trapezius. In type-V injuries (Fig. 1e), the degree of separation is greater because of the concomitant disruption of the deltotracheus fascia attached to the lateral end of the clavicle, allowing the end of the clavicle to lie subcutaneously. In the very rare type-VI injury (Fig. 1f), the clavicle is displaced inferiorly and comes to lie below the coracoid process underneath the conjoint tendon. MRI of a limited number of injuries¹⁵ has shown some inconsistencies in this classification and questioned the current understanding of the disruption of the soft tissue. At operation the findings typically support the current classification,¹⁶ although more studies on the imaging of these injuries may yet challenge this.

'Pseudodislocation' is an unusual injury seen in children and adolescents, in which the joint is dislocated, but with the coracoclavicular ligaments intact and remaining attached to a periosteal sleeve stripped off the distal clavicle.¹⁷ A second uncommon variant is a separation of the joint in which the coracoclavicular ligaments are intact but there is a bony avulsion fracture of the coracoid process.¹⁸ This may involve the superior glenoid and may be difficult to assess on a standard anteroposterior radiograph. CT or MR arthrography is useful in assessing the size and extent of displacement of the fragment.

The use of weight-bearing views to classify and to provide prognostic information for injuries to the acromioclavicular joint has been described¹⁶ and some practitioners apply them selectively.¹⁹ Such views are not commonly

Fig. 2

Anteroposterior radiograph of the acromioclavicular joint showing a type-IV injury in a 24-year-old-man who fell playing rugby.

taken after acute sprains (types I and II) although they are sometimes used to assess instability in these injuries.²⁰

Goss²¹ defined the concept of the superior shoulder suspensory complex, which is a bony and soft-tissue ring composed of the superior glenoid, the coracoid process, the coracoclavicular ligaments, the distal clavicle, the acromioclavicular joint and its ligaments, and the acromion. As with injury to the pelvic ring, damage to one part of the superior shoulder suspensory complex must also produce disruption of another portion of the osteoligamentous ring, leading to the so-called 'double disruptions'. By definition, all type-III to type-VI dislocations fall within this category, since both the acromioclavicular and coracoclavicular ligaments are injured. Dislocations which occur together with fracture of another component of the complex such as the lateral clavicle or coracoid process, are also double disruptions. This produces an unstable situation which may result in adverse long-term effects on healing and function. It has therefore been suggested that these injuries should be considered for operative reduction and stabilisation of at least one component of the disruption.²²⁻²⁴

Bifocal and other combined patterns of injury. Bifocal injuries, in which an acromioclavicular separation occurs in combination with another discrete injury to the shoulder girdle remote to the superior shoulder suspensory complex, are relatively uncommon. Diaphyseal fractures of the clavicle can be associated with an injury to the acromioclavicular joint and separation may be difficult to diagnose, particularly with marked displacement of the clavicular fracture.^{24,25} Less common still is a complete separation of the clavicle, the 'floating clavicle', with dislocation of both acromioclavicular and sternoclavicular joints.²⁶⁻²⁸

Scapulothoracic dissociation occurs when the scapula is torn away from the chest wall, effectively producing a closed amputation of the upper limb. This injury is rare and occurs almost exclusively after high-energy trauma in

which there is a traction injury to the arm. Any of the three bones and joints of the shoulder girdle may be affected, and separation of the acromioclavicular joint is often encountered as part of the disruption of the sternoclavicular-acromial linkage. Injuries to the vasculature and the brachial plexus are common, and a widened scapular index, as measured from the midline of the spine to the medial border of the scapula, when seen on an anteroposterior radiograph of the chest, is pathognomonic.

Clinical assessment

The clinical diagnosis of an acute acromioclavicular injury is usually relatively simple since the pain is commonly localised accurately to the area of the joint. Marked swelling, abrasions and ecchymoses may be seen over the affected joint, although compromise of the skin is unusual. Concomitant injury to neurovascular structures is uncommon, except in association with another injury to the shoulder girdle. The joint is tender to palpation and the clavicle often feels mobile, the 'piano-key' sign. Forced adduction of the symptomatic arm across the chest, the Scarf test,²⁹ is also likely to reproduce pain at the injured joint. In the active compression test of O'Brien et al³⁰ the arm is elevated forward by 90°, adducted by 10° to 15°, initially with the forearm fully pronated and then supinated, while the examiner applies resisted downward pressure on to the hand. The test is positive if pain is produced by resisted pronation and relieved by resisted supination. It is specific for injury to the acromioclavicular joint only if pain is localised to the joint. If the test produces a deep-seated pain 'inside' the shoulder, this is suggestive of symptoms related to the superior labrum or biceps tendon.

The grading of the injury is made on radiological examination as determined by the extent of displacement of the articular surfaces (Fig. 2). A 10° cephalad view centred on the acromioclavicular joint, the Zanca³¹ view, further highlights vertical displacement. An orthogonal view is required to assess the degree of anteroposterior translation of the surfaces of the joint.

Ultrasound and MRI are not widely used, but can be employed to detect effusions from the joint, assess the extent of injury to the ligaments and the deltoid aponeurosis^{15,32} and to determine the degree of degenerative changes in patients who develop delayed symptoms.³³

In some patients who present late with chronic discomfort in the shoulder girdle after injury, the diagnosis of pain in the acromioclavicular joint may be less clear. Chronic symptoms may occur after both minor and severe injuries to the joint, but are more common in association with higher levels of disruption. There may be more than one contributory cause for symptoms in these patients and all potential sources must be addressed at the time of any secondary reconstructive procedure (Table I). Up to half of the patients with osteolysis of the lateral end of the clavicle present with a history of a discrete injury to the shoulder.³⁴ This condition, which usually settles with non-operative

Table 1. Differential diagnoses in patients with chronic shoulder pain after injury to the acromioclavicular (AC) joint

Cause	Symptoms	Clinical findings	Investigations	Treatment options
Pain in the AC joint from osteoarthritis or disc disease	Pain localised over the AC joint	Localised tenderness in the AC joint. Positive Scarf/O'Brien ³⁰ tests	Plain radiography Steroid injection into the AC joint MRI/bone scan	Physiotherapy, modification of activity, oral analgesia Excision of the AC joint
Osteolysis of the distal clavicle	Pain over the lateral clavicle	Localised tenderness and swelling of the lateral clavicle	Characteristic plain radiological and MRI appearances	Physiotherapy, modification of activity, oral analgesia Excision of the AC joint
Instability of the AC joint	Pain localised over the AC joint	Localised AC joint pain. Positive Scarf/O'Brien ³⁰ tests 'Piano-key' sign	Plain and stress radiography	Physiotherapy Ligament reconstruction
Rotator-cuff impingement or tear	Painful arc or shoulder weakness Cuff tear, usually in older patients	Positive impingement signs. Rotator-cuff weakness	Subacromial injection of steroid USS*/MRI for cuff tear	Subacromial injection of steroid for impingement Subacromial decompression Repair of cuff tear
Adhesive capsulitis	Diffuse shoulder pain Night pain Shoulder stiffness	Global restriction of passive movement, especially in external rotation	Clinical diagnosis	Physiotherapy Distension arthrography Manipulative/arthrolysis
Thoracic outlet syndrome	Dysaesthesia Motor weakness	Arm position can reproduce symptoms Specific tests insensitive	Chest radiography Nerve-conduction studies MRI of the neck and thoracic outlet	Physiotherapy Surgical decompression
Superior labral tears (SLAP lesions)	Shoulder pain on overhead activities	Positive O'Brien/Speed test	MRI arthrography Arthrograph	Physiotherapy SLAP repair or debridement
Complex regional pain syndrome	Diffuse shoulder pain Stiffness Neurological dysfunction	Reduced movements, skin changes, altered feeling, swelling distally	Clinical diagnosis Radiography may demonstrate osteopenia	Multidisciplinary approach: Physiotherapy Pain control (pain clinic) Oral medication Second-line oral therapies Regional nerve blocks

*USS, ultrasound scan

treatment, is characterised by pain and localised discomfort over the joint, together with cystic changes and resorption of the distal clavicle which can be seen on conventional radiographs.³⁵ Osteoarthritic changes are restricted to patients with type-I and type-II injuries,³⁶ since the greater separation of the bone ends in higher-grade injuries prevents the development of this complication. However, degenerative changes in the articular disc and lateral end of the clavicle are often encountered at operation and may be a source of pain in a higher-grade injury.

Isotope bone scanning and MRI may be useful in discriminating the source of symptoms, and abolition of the symptoms by an ultrasound-guided injection of local anaesthetic into the joint may be helpful in clarifying whether the symptoms arise from the joint itself.³⁷

The treatment of acromioclavicular joint injury

The aim should be to return the patient to the level of function before injury, with a pain-free, strong and mobile shoulder.

Conservative treatment

This is almost universally applicable to type-I and type-II injuries. The most common form of non-operative treatment involves simple analgesia, topical ice therapy and rest

in a sling to give relief from symptoms. A broad arm sling is preferable to a collar and cuff because it supports the elbow and tends to minimise sagging of the shoulder. The sling should be discarded once the acute symptoms have settled, typically after the first week after injury. It is unusual for the patient to require formal physiotherapy, since weakness and stiffness of the shoulder are seldom a problem.¹⁰ A variety of techniques of external strapping and commercially-manufactured braces is available. There is no evidence that any of these can reduce subluxation of the joint,³⁸ and they may give rise to local skin problems, stiffness of the shoulder or non-compliance.

Contact sports and heavy lifting should be avoided for eight to 12 weeks after injury. Aching discomfort may be felt in the area of the injured joint for up to six months. A substantial number of patients have reproducible joint pain after conservative treatment, and up to one-third of those with type-I and type-II injuries has pain on activity at longer term follow-up.³⁹ This may be due to degenerative changes within the joint, or in type-II injuries to instability, resulting from injury to the joint capsule. Operation may be considered for these patients if they have ongoing symptoms at three months after the original injury.

Conservative treatment also remains the preferred initial mode of management for most type-III injuries because of

the excellent prognosis in most patients with this injury.⁴⁰⁻⁴² After rehabilitation, the strength and endurance are similar to those of the uninjured shoulder,^{41,43} and most patients return to their previous level of employment, sport and recreational activities. Secondary surgical reconstruction is seldom needed. The subluxation persists, but typically produces minimal cosmetic problems and is well tolerated, and the satisfactory functional results appear to be maintained in the longer term.⁴⁴ Despite a lack of compelling evidence, it is often suggested that patients with a type-III injury who have a high level of functional demand on the shoulder may benefit from early intervention.^{45,46} However, the current view remains in favour of conservative management of acute type-III injuries, and a survey of orthopaedic surgeons treating professional throwing athletes in North America revealed an overall preference for such management.⁴⁷

Operative treatment

Operation is used to treat medically-fit patients with type-IV and type-V injuries.^{4,48,49} Type-VI injuries are very rare, and almost all reported cases have been treated surgically.^{4,50,51} A wide variety of operative procedures has been described, but none has been shown to be notably superior to the others. The latest more minimally-invasive techniques appear to be promising, but well-designed prospective follow-up studies should be performed before their use becomes widespread.

While the range of operative approaches is considerable, certain underlying principles are recognised:

- 1) accurate reduction of the acromioclavicular joint must be achieved, by correction of the inferior sag of the scapula, together with any anteroposterior translation of the joint surfaces;
- 2) an acutely reduced joint is inherently unstable, and will re-displace unless the disrupted ligaments are either repaired or substituted. Substitution may be performed using either an autograft from a local or distant source, or an allograft, and must closely mimic the normal joint restraints;
- 3) the reduction and ligament reconstruction must have sufficient immediate stability to prevent acute re-displacement or else be protected temporarily until the repair heals;
- 4) rigid implants used for temporary stabilisation of a ligament reconstruction must be removed once the repair has consolidated, or they will eventually break, loosen or produce stiffness in the shoulder.

The main sources of variation amongst the more common techniques which are currently performed are best summarised in four categories: the timing of surgery, the choice of surgical approach, the choice of ligament reconstruction and the technique to stabilise the reconstruction.

Acute repair or delayed reconstruction? Accurate reduction of the joint is easier when surgery is performed within the first two weeks after injury, when the ruptured ligamentous restraints can often be repaired directly. Complete reduc-

tion of the joint is more difficult when several months have elapsed after the injury, and the native ligaments may then be difficult to identify and repair. Most techniques of reconstruction in the acute injury involve reduction of the joint, ligamentous repair and stabilisation of the joint, whereas in most delayed reconstructions an excision of the lateral end of the clavicle is performed before reduction, with stability restored by ligamentous substitution.

Although it may be felt that acute reconstruction would be associated with a more favourable outcome, it is usually reserved for higher-grade injuries (type IV to type VI), double disruptions of the superior shoulder suspensory complex or when there is an associated soft-tissue or neurovascular injury. Operative treatment for type-III injuries is usually only considered for those patients who have persistent symptoms after a trial of conservative care for three months. Acute repair of these more common lower-grade injuries results in a substantial degree of over-treatment of patients who may not develop symptoms after conservative management. Despite the considerable technological advances in the treatment of these injuries, acute surgery still carries substantial risks of early failure of the reconstruction and other serious soft-tissue complications.

It is important to establish a positive diagnosis in patients who have chronic symptoms after initial conservative treatment in order to prevent inappropriate surgery. Excision of the distal 5 mm to 10 mm of the clavicle alone, the Mumford procedure,^{52,53} has been used successfully in treating chronic problems resulting from degenerative joint disease after a stable type-I or type-II injury, and in refractory cases of post-traumatic osteolysis which fail to respond to conservative measures.³⁴ It is important not to perform an excessive resection which may destabilise the joint.⁵⁴ Injury to the residual superior capsular restraints in direct open approaches may also cause instability of the joint. This may account for the better results after arthroscopic excision, which is usually combined with subacromial decompression, performed from the bursal side.⁵⁵⁻⁵⁷ Excision of the distal clavicle alone is not appropriate for higher-grade injuries if there is associated symptomatic instability of the joint. In these circumstances ligamentous reconstruction should also be performed, as described below.

Surgical approach: open or arthroscopic? Open exposure of the dislocation using a 'bra-strap' incision remains the most common surgical approach. Although this causes more prominent scarring, it is technically easier, allows direct visualisation of the reduction of the joint and removal of any degenerative disc material. Injury to the important delto-trapezius aponeurosis can only be assessed and repaired by an open surgical approach.⁵⁸

Advances in instrumentation and implants have produced a recent trend towards the use of arthroscopic approaches. Many of these techniques are similar to those used for ligamentous reconstruction in the knee. The accuracy of reduction of the joint is more difficult to assess

Fig. 3

Diagram showing the 'classic' procedure of Weaver and Dunn.⁵⁹ This consists of transfer of the coracoacromial ligament into the lateral end of the clavicle after excision of its lateral 5 mm to 10 mm.

arthroscopically, although the use of intra-operative fluoroscopy may help. Arthroscopic surgery causes less injury to the soft-tissue envelope, but there is a steeper learning curve for its use when compared with open reconstructive procedures.

Which ligament reconstruction? There are several types of repair.

Techniques using native ligament. Repair of the ruptured coracoclavicular and acromioclavicular ligaments is only possible when it is performed within the first two weeks after injury, and as an open procedure. The joint is first reduced under direct vision and similar techniques to those described for tendon repair are then used to suture the torn ligaments directly. The repair must be protected by temporary rigid fixation or transfixation of the joint until ligamentous healing occurs. The problems associated with these techniques include the technical difficulty of surgical access and of suturing mid-substance ligamentous injuries, typically of a 'shaving-brush' quality, and the uncertainty regarding the structural integrity of the repair.

Ligament substitution with local ligaments or tendons. Transfer of the coracoacromial ligament was introduced by Weaver and Dunn⁵⁹ and remains the mainstay of delayed stabilisation (Fig. 3). The procedure as originally described carries a recognised risk of ongoing pain, which may be related to instability and recurrent subluxation because of failure of the fixation. A number of modifications have been introduced,^{19,60,61} and these have been used successfully in the management of acute type-III dislocations, as well as in patients with more chronic symptoms.^{61,62}

The procedure as originally described has only approximately 30% of the strength and 10% of the stiffness of the intact ligaments, with failure occurring mainly at the suture attaching the transferred ligament.⁶³ The mean laxity after

reconstruction, of approximately 42 mm in an anteroposterior plane and 14 mm vertically, compares with the 8 mm and 3 mm, respectively, in intact ligaments.⁶⁴ These parameters can be improved significantly by augmentation of the coracoclavicular suture.^{60,64,65} Newer suture materials (Fiberwire; Arthrex Inc., Naples, Florida) and more anatomical techniques may perform better, and approach the load to failure of the intact ligaments.⁶⁰ Both arthroscopically-assisted and all-arthroscopic techniques have now been described to transfer the coracoacromial ligament, augmented by either autograft or synthetic suture material.^{66,67} It remains to be seen whether these techniques produce results comparable with those of the open techniques.

The conjoined tendon has also been used as a local graft to create a 'dynamic muscle transfer' stabilisation of the lateral clavicle. There are several variations of this procedure, including direct transfer of the tendon superiorly, either alone,⁶⁸ or together with a portion of osteotomised coracoid origin.^{69,70} The operation carries the risk of over-tightening of the coracoclavicular space. A proximally-based transfer has therefore been developed. This retains the origin of the tendon and divides its lateral half distally, then reverses the tendon and implants it into the lateral end of the clavicle^{71,72} (Fig. 4). Biomechanical studies and clinical experience suggest that the conjoined tendon has better properties and greater consistency of quality of the graft compared with those of the coracoacromial ligament.^{69,71,72} It also offers an alternative source of a graft in revision procedures when the coracoacromial ligament has already been harvested. However, when a partial osteotomy of the coracoid is performed there is a risk of subsequent fracture,⁷³ and transfer of the conjoined tendon to the clavicle has been associated with injury to the musculocutaneous nerve.^{74,75}

Other techniques of ligament substitution. Coracoclavicular cerclage is a well-established technique and has been carried out using numerous materials including tendons, wire loops and synthetic ligament substitutes such as Dacron, Mersilene tape, or polydioxanone.⁷⁶⁻⁷⁹ This form of reconstruction does not rely on biological healing, and temporary rigid stabilisation of the joint after operation is not usually required.⁶⁰ Tendons such as semitendinosus, gracilis and the toe extensors have shown strength and stiffness similar to those of the native ligaments,^{65,80} and the use of peroneus brevis has also been described.⁸¹ The weak point of the reconstruction is the method of securing it, but tying a knot in the graft, or using interference screws, may help to overcome this problem.^{60,65} A cerclage graft using semitendinosus with suture augmentation has been described using a minimally-invasive approach.⁸² One end of the graft is sutured to a plate and the other fixed to the clavicle, using a biotenesis screw. Earlier cerclage techniques were typically less stable than those using intact ligaments,⁶⁴ but the latest generation of more robust, non-absorbable sutures perform better.⁶⁰

Fig. 4

Diagram showing transfer of the lateral half of the conjoined tendon to the distal clavicle augmented by Endobutton fixation of the acromioclavicular joint. The arrow shows the pivoting at the origin of the conjoined tendon and the movement of the distal end of the tendon from A to A* where it is sutured into the end of the clavicle. The close proximity of the musculocutaneous nerve (M) is highlighted.

Fig. 5

Radiograph of the acromioclavicular joint showing twin endobuttons *in situ*. The endobutton suture technique was used to augment a conjoined tendon transfer (as shown in Fig. 4) in a 23-year-old man six months after a type-III injury which remained significantly symptomatic despite conservative treatment.

To prevent excessive anterior subluxation, which may occur using complete clavicular cerclage, the graft may be passed through a drill hole in the anterior third of the clavicle rather than over its posterior aspect.⁷⁷ Alternatively, two holes may be drilled in the clavicle at the site of insertion of the previous ligament to produce a more anatomical reconstruction. The typical attachment of the conoid ligament is 45 mm medial to the end of the clavicle in its posterior half and of the trapezoid 15 mm lateral to this in the midline.⁶⁰ A double-suture technique may also be adopted when utilising twin drill holes.⁷¹

Various modifications have been made to the original techniques of coracoclavicular cerclage. The coracoid cerclage may be retained, or direct fixation to the bone achieved using either drill holes, endobuttons or suture anchors.⁸³⁻⁸⁵ These may help to minimise the risk of injury to underlying neurovascular structures and avoid dislocation of the lower portion of the cerclage loop off the front of the coracoid.⁸⁴ Repair has also been performed using a continuous loop of suture running between two Endobuttons, which are passed through the lateral clavicle and coracoid⁸⁶ (Figs 4 and 5). These techniques lend themselves particularly well to arthroscopic insertion in which a custom-made drill guide is used to assist in the placement of the drill hole in the coracoid. Few data are available on the clinical outcomes of these techniques, although early reports are promising.⁸⁷

Although techniques of cerclage provide more secure reconstruction of the reduction, failure may still occur, from a stress fracture of either the clavicle or the coracoid as a result of a 'cheese-wire' effect, or by failure of the graft

itself.^{63,88,89} The use of an absorbable suture may reduce the risk of fracture and may achieve satisfactory results, although, more commonly, non-absorbable implants are used and retained.⁹⁰ Aseptic foreign-body reactions have also been reported using synthetic grafts,⁹¹ but this is probably less common with the newer suture materials.

Protection of the soft-tissue repair. The arm is placed in a sling for three to six weeks after the surgery in order to avoid early failure. Temporary methods of rigid stabilisation of the joint have also often been used to protect soft-tissue repairs which rely on biological healing of the graft. These must be removed once the soft-tissue repair has consolidated sufficiently to withstand normal joint forces, usually at six to 12 weeks after the initial operation. If removal is carried out too soon there is a risk of rupture of the graft and re-displacement of the joint, whereas if it is performed too late there may be stiffness in the shoulder or failure of the implant.

Fixation using a coracoclavicular screw, first described by Bosworth,⁹² has been the most widely-used technique to provide temporary stabilisation of the joint^{93,94} (Fig. 6). However, it is technically difficult to achieve good placement of the screw in the narrow corridor of bone in the horizontal portion of the coracoid, irrespective of whether this is performed as an open or fluoroscopically-assisted technique. Percutaneous insertion of the screw has an unacceptably high rate of technical failure,⁹⁴ but the use of arthroscopy to visualise the coracoid directly may improve its placement.⁹⁵ Even a technically-satisfactory fixation is subject to cyclical loading by movements transmitted from the adjacent joints and is therefore

Fig. 6

Anteroposterior radiograph of a coracoclavicular screw used to treat a 45-year-old man who fell down several steps, sustaining a type-V injury of the acromioclavicular joint.

Fig. 7

Anteroposterior radiograph of an acromioclavicular joint hook plate used in the treatment of a 35-year-old man who fell playing football.

prone to failure by cut-out or loosening. A prospective, randomised study has compared fixation by a coracoclavicular screw with non-operative treatment.⁴⁵ Better results were seen overall in those managed conservatively, although a subset of markedly-displaced injuries benefited more from surgery.

In the past Kirschner wires have been used extensively to transfix the acromioclavicular joint temporarily after reduction. These give relatively poor fixation,⁵⁸ may precipitate osteoarthritis within the joint, and severe complications and even fatalities may occur from distant migration of the wire to the lung, spinal cord or neck. Given the wider range of better implants which is now available, the use of these wires is now contraindicated.⁹⁶⁻⁹⁹

A modified dynamic compression plate (Synthes, Welwyn Garden City, United Kingdom) with a lateral hook designed to engage under the posterior part of the acromion, has been used successfully to maintain reduction of acute dislocations (Fig. 7).^{81,100,101} This osteosynthesis closely reproduces the stability of the intact joint,¹⁰² but its prolonged retention can produce stiffness of the shoulder, clavicular osteolysis and peri-prosthetic fracture, whereas its removal at an early stage may lead to re-subluxation of the joint.¹⁰³ Removal of the implant is therefore recommended at between eight and 12 weeks after the procedure. The use of a novel alloy coracoclavicular hook has been described with satisfactory results,^{104,105} but this still requires early removal.

In the newer minimally-invasive and arthroscopic techniques, insertion of hardware to stabilise the soft-tissue repair is not possible, and they rely on the immediate stability of the graft construct to maintain the clavicle in the reduced position.

The treatment of acromioclavicular dislocation with associated injuries

Guidelines for the best treatment for these injuries are difficult to produce, owing to their rarity, and the considerable variation in the patterns of injury. However, there appears to be a general trend towards operative treatment of the acromioclavicular joint in combined injuries to restore mechanical stability and to facilitate rehabilitation.

Most 'pseudodislocations' can be managed conservatively in children,¹⁰⁶ although operative reduction of the dislocation and direct repair of the periosteal sleeve may be performed if displacement is severe.¹⁷ Only a small number of cases have been reported in which a fracture of the coracoid process has occurred in association with dislocation of the acromioclavicular joint.²² Most have occurred in young adults, and successful outcomes have been reported with both conservative and operative treatment.^{23,107-109}

Smaller case series have also recorded successful outcomes after operative stabilisation of the acromioclavicular joint in patients with ipsilateral acromioclavicular dislocation and a mid-clavicular fracture,²⁴ those with dislocation of both ends of the clavicle ('floating clavicle'),²⁸ and in patients with an ipsilateral fracture of the neck of the glenoid and fracture of the clavicle or injury to the acromioclavicular joint.¹¹⁰

In the presence of a scapulothoracic dissociation, if there is an unreconstructable vascular injury or if the injury has produced catastrophic disruption of the brachial plexus, early amputation is advocated,¹¹¹ whereas only operative restoration of soft-tissue and bony stability may be required if the limb is viable, with a prospect of a useful return of neurological function.

Complications of injuries to the acromioclavicular joint

For the more common complications such as osteoarthritis of the joint, clavicular osteolysis and the regional pain syndrome, it is usually impossible to assess whether the condition has developed as an inevitable consequence of the original injury or as a result of the treatment. Most of the complications specific to, and occurring as a consequence of, operative treatment have been described. However, there are a number of shared complications which merit discussion.

Post-operative superficial wound infection is not uncommon and can usually be managed conservatively. However, the most feared complication of all operative methods of treatment for these injuries is deep sepsis.¹¹²⁻¹¹⁴ This area of the shoulder girdle has acquired a reputation for having a high risk for this complication. This is due to a number of factors including the subcutaneous location of the joint, the requirement for extensive soft-tissue dissection to perform the surgery, and the use of allografts, metal implants and non-absorbable sutures and tapes to stabilise the joint. Established deep infection usually requires extensive soft-tissue debridement, removal of all foreign material from the wound and prolonged antibiotic therapy. This complication is almost always associated with failure of the reconstruction and a poor functional outcome.

Although all the accounts of the different techniques record a low rate of failure, the multiplicity of procedures, the lack of a generally-accepted method of operative treatment and the number of reports documenting specific operative complications, suggest that all operative techniques carry a substantial risk of failure of the implant, leading to re-subluxation of the joint. Partial re-subluxation may not always be associated with a poor outcome and is often treated conservatively. Complete subluxation is usually associated with residual symptoms, and there are now some reports of successful revision operations.⁸⁰

Even with successful reconstruction, local prominence and dysaesthesia of the wound are common sequelae of operative intervention. Some patients also describe weakness of the arm, paraesthesiae, or other vague symptoms suggestive of entrapment of a nerve root or traction on the brachial plexus. These thoracic-outlet-type symptoms may be related to the inferior position of the shoulder girdle relative to the thorax and must be carefully distinguished from other sources of chronic pain after this injury. Ossification within the torn coracoclavicular ligaments is often seen on radiographs both after surgical reconstruction or conservative treatment. It is uncertain whether this is a source of ongoing symptoms.

Injury to the brachial plexus and subclavian vessels occasionally occurs during operative treatment. Instruments used for the insertion of implants into or around the coracoid increase the risk of this complication because of the proximity of the neurovascular structures inferiorly. The injury may be detected at the time of surgery, when imme-

diately repair is indicated. Delayed presentation with an arteriovenous fistula or a false aneurysm may also occur after a vascular injury from penetration by a drill or screw which was not detected at the time of surgery.

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