SURGICAL MANAGEMENT OF UPPER LIMB INJURIES IN CYCLISTS

– Written by Richard Knight, Len Funk, Adam Watts and Mike Hayton, United Kingdom

Upper limb injuries are extremely common in cycling and can be separated into non-traumatic conditions, such as peripheral nerve compressions, and acute traumatic injuries, such as scaphoid and clavicle fractures. This article aims to give an overview of these injuries and injury patterns which commonly affect elite cyclists, how to minimise their impact and how they can be managed surgically.

Non-traumatic pathologies which commonly affect the hand of the cyclist are ulnar nerve compressions at the Guyon's canal, median nerve compressions at the carpal tunnel and hypothenar hammer syndrome. Figure 1 shows the superficial location of both the median and ulnar nerve and also the ulna artery at the wrist. In this axial 3T MRI the ulna nerve is actually seen to be split into the sensory and motor branch as it passes through Guyon's canal.

ULNAR NERVE COMPRESSION ('HANDLE-BAR PALSY')

The ulnar nerve passes along the volar/ulnar aspect of the wrist, passing through Guyon's canal and into the hypothenar eminence and hand. This makes it particularly susceptible to compressive injury in cyclists while they are gripping on the hoods or on the drops, as this applies the most direct pressure at the Guyon's canal[1]. The ulnar nerve supplies sensation to the ulnar portion of the hand and the little and ring fingers. Its motor branches supply the intrinsic muscles of the hand (hypothenar muscles, adductor pollicis, the interossei and the fourth and fifth lumbricals). It is important to remember that depending on which zone of Guyon's canal is affected, symptoms can be motor only, sensory only or a mixed pattern. This means that although classic presentation of ulnar nerve

palsy at the wrist causes pain and altered sensation to the little and ring fingers, if the compression is exclusively affecting the motor branch, cyclists may present with painless wasting of the interossei muscles between the metacarpals, wasting of the first web space and clawing of the little and ring fingers. Although predominantly a clinical diagnosis, nerve conduction studies can confirm the diagnosis and localise the site of compression. The majority of cases settle with non-operative management, although surgical decompression and exploration is required as a matter of urgency when there is motor nerve involvement. It should be noted however that in some severe cases, particularly with motor symptoms, the symptoms and muscle loss may not fully recover despite decompression. This highlights the need for increased awareness and early operative measures when motor
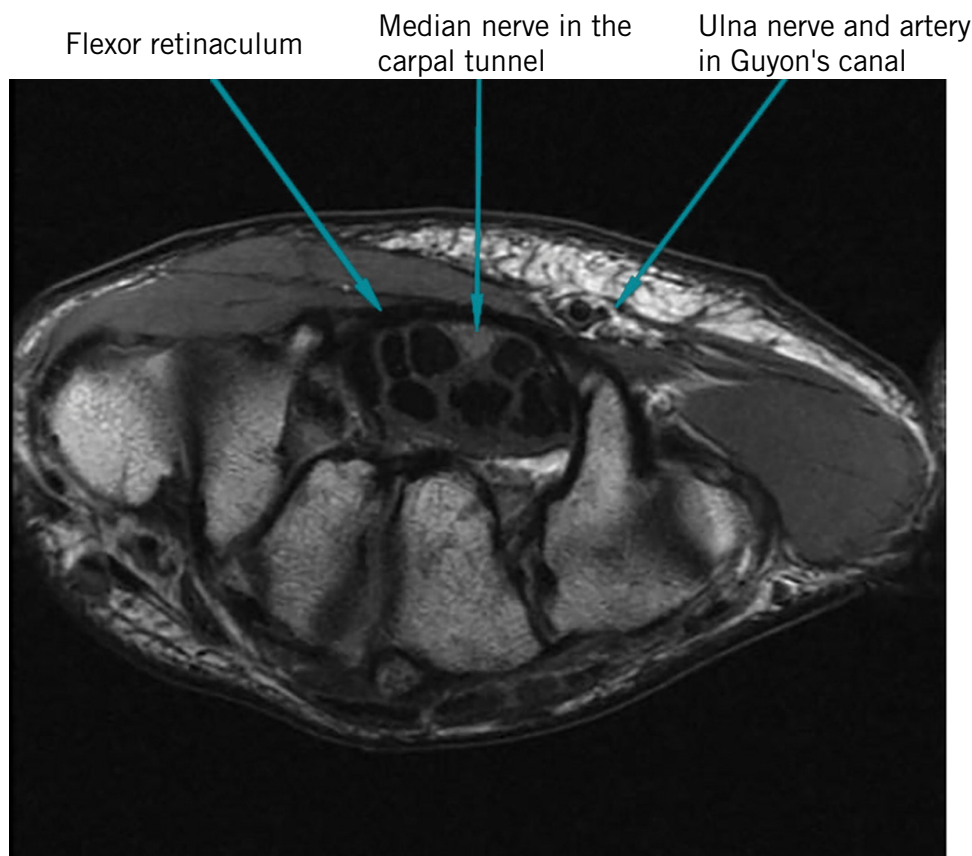
Flexor retinaculum   Median nerve in the carpal tunnel   Ulna nerve and artery in Guyon's canal

Figure 1: 3T MRI axial section of the wrist showing the superficial position of the nerves. Both the sensory and motor branches of the ulnar nerve can be seen.

symptoms and signs of weakness and wasting are identified. Non-operative measures for sensory involvement include thicker, padded handlebar tapes and padded gloves to minimise the contact pressures at Guyon's canal. One study showed a decrease in peak pressure over the palm by 10 to 29% simply by using protective gloves[1]. Where possible, adoption of a cycling position which minimises the weight through the upper limb should be encouraged. All riders should also be aware of their hand position and to change this periodically throughout a ride. Despite the perception that ulnar nerve/handlebar palsies are a 'chronic' condition, it should be remembered that permanent ulnar nerve damage can occur within hours or within a single ride and as a result, cyclists should be aware of these strategies to reduce the risk of permanent injury.

MEDIAN NERVE COMPRESSION

Median nerve compression at the carpal tunnel also frequently affects cyclists. It tends to affect mountain bikers and road cyclists who prefer to ride on the tops of the handlebars, as the wrist tends to be more extended in these riders, but affected patients are not limited to these grip patterns. Typical symptoms include reduced sensation and pins and needles affecting the thumb, index and middle fingers, rarely with weakness or wasting of the thenar eminence. Again, the diagnosis is often clinical in classical cases but nerve conduction studies can confirm the site of compression in equivocal cases. Although likely to be a localised compression neuropathy, other medical causes and more proximal lesions at the elbow and cervical spine should always be excluded. The majority of cases resolve with non-operative measures, similar to those for ulnar nerve compression. An image-guided steroid injection around the median nerve may improve symptoms but tends to have a transient effect. If symptoms do not improve with non-operative measures, a surgical release of the carpal tunnel should be considered.

HYPOTHENAR HAMMER SYNDROME

This is a rare and probably under-reported condition which causes digital ischaemia as a consequence of an ulnar artery aneurysm or thrombosis. This is usually related to repeated blunt trauma to the hypothenar eminence, although a single, significant blunt trauma can cause sufficient damage to the vessel to cause subsequent thrombosis or aneurysms. These changes frequently lead to distal ischaemia, ulceration and ultimately necrosis. As well as cyclists, sports which involve repeated trauma to the hypothenar eminence, such as golf, hockey, volleyball and baseball, can be affected. Patients can present with a sudden acute event or a more gradual picture. Symptoms generally consist of pain over the hypothenar eminence and any of the fingers, although the ring finger tends to be more commonly affected. Cold sensitivity and paraesthesia are also common. Clinical examination may reveal subtle blanching of the digits with splinter haemorrhages, up to digital ischaemia, ulceration and gangrene. Rarely, a palpable mass representing an ulnar artery aneurysm can be identified. Treatment depends on the acuteness of presentation and the severity of symptoms. In mild cases presenting chronically, activity modification and non-surgical treatments can be sufficient. In acute cases with

Figure 2: Plain radiograph of a non-union proximal pole scaphoid. Increased sclerosis of the proximal pole is also visible, suggesting avascular necrosis that will eventually fragment.

digital ischaemia some form of surgical intervention in the form of fibrinolysis or embolectomy is required, occasionally with complete excision of the affected ulnar artery segment and subsequent reconstruction.

SCAPHOID FRACTURE

Although many injuries in the hand and wrist occur due to falls by cyclists, one of the commonest and potentially most serious is a fracture of the scaphoid bone. Precise mechanisms of injury can vary, but any fall onto an outstretched hand in which there is pain around the wrist should raise the suspicion of a scaphoid fracture. Initial symptoms are radial-sided wrist pain, lack of wrist extension and difficulty loading the wrist in extension. The three most reliable and reproducible areas to test scaphoid tenderness are:

- The anatomical snuff box.
- Over the greater tuberosity on the volar surface of the scaphoid.
- Pain on performing the scaphoid compression test.

Lack of wrist extension compared to the opposite side is a particularly important clinical sign and should alert the clinician to wrist internal derangement that may be a scaphoid fracture or intrinsic ligament injury.

Plain radiographs often reveal a scaphoid fracture, however radiographs may be normal, even with a fracture and, if suspected, should be repeated after 10 days of immobilisation. MRI is now commonly used to exclude or diagnose an acute scaphoid fracture and will show the fracture and oedema immediately. A timely diagnosis is important to reduce the risk of scaphoid non-union and avascular

necrosis leading to arthritis. Figure 2 shows a scaphoid proximal pole non-union. The proximal pole has become sclerotic and will eventually fragment due to avascular necrosis.

Scaphoid fractures can broadly be placed into three categories: distal pole, waist and proximal pole fractures. This is a reflection of the relatively poor blood supply to the scaphoid bone which flows in a retrograde direction from distal to proximal. Any fracture of the scaphoid potentially disrupts the blood supply and can lead to avascular necrosis of the proximal scaphoid. Traditionally distal pole fractures have been treated in plaster for 6 to 12 weeks. A thumb extension does not need to be incorporated in this plaster. Proximal pole fractures have a poor union rate and can develop avascular necrosis. They are therefore almost always treated via an open or percutaneous fixation

with a compression screw. Displaced scaphoid waist fractures should also be fixed surgically, but evidence is divided on the management of undisplaced scaphoid waist fractures, with much research ongoing. Given no clear consensus in the management of undisplaced waist fractures, many surgeons treating elite athletes would advocate fixation of these fractures to permit early return to training and/or competitions and avoid the problems that prolonged immobilisation may cause in the athlete, such as skin maceration due to sweating under the cast. Although advice regarding return to sport varies, many surgeons who fix fractures would not require prolonged casting postoperatively and an early return to non-contact or low-impact activities may be offered. However, these activities are likely to be restricted until bony union is confirmed, usually via CT scan.

THE ELBOW

Fractures around the elbow

Typical fractures seen following a fall from a bike are radial head fractures, that may be part of a fracture dislocation and olecranon fractures. These injuries may be open and are often heavily contaminated with grit from the road. This requires immediate attention with surgical cleaning to reduce the risk of infection.

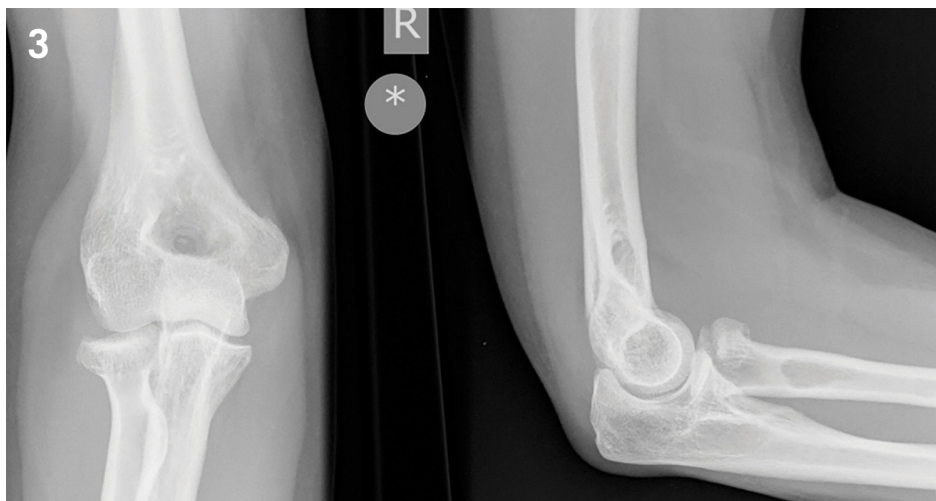Radial head fractures can involve only part of the radial head or the head and

Any fracture of the scaphoid potentially disrupts the blood supply and can lead to avascular necrosis of the proximal scahpoid
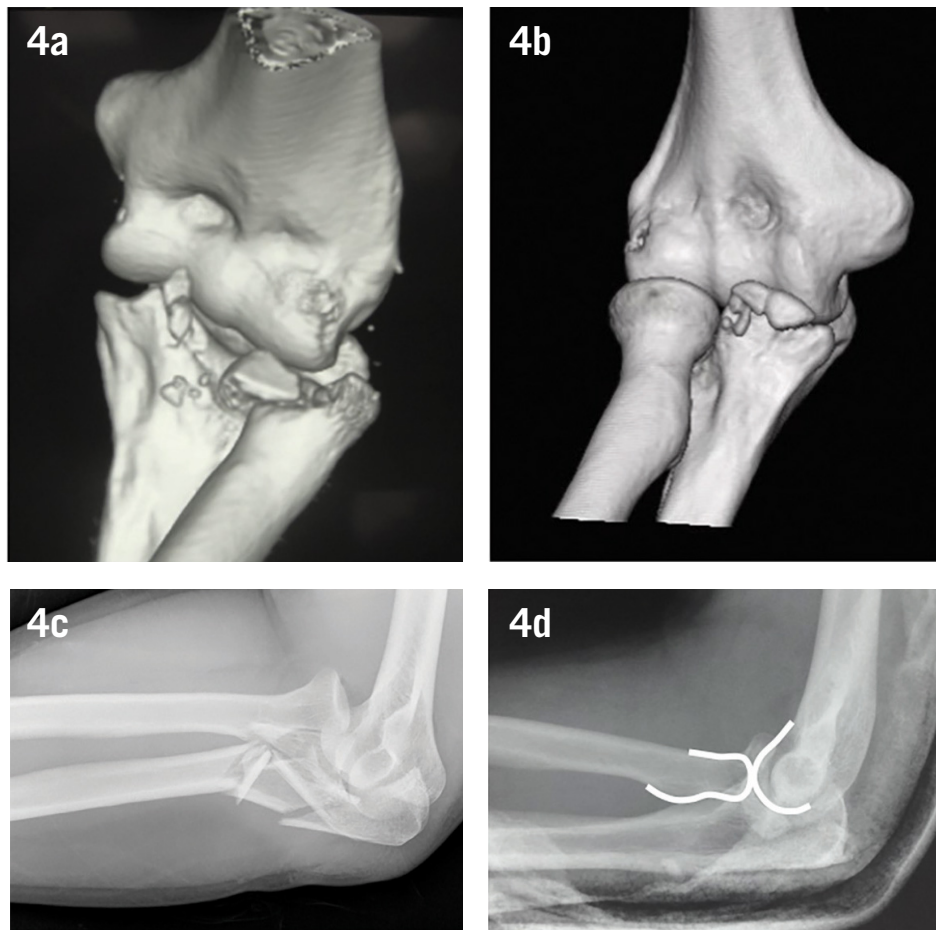
Figure 3: Radial head fracture.

Figure 4: Elbow fracture dislocations. **(**a) terrible triad, (b) posteromedial fracture dislocation, (c) monteggia fracture dislocation, (d) Essex-Lopresti lesion.

neck of the radius. Most partial radial head fractures can be treated with early active movement and pain control, with satisfactory outcomes by about 6 weeks. The cyclist should be advised that while they may not regain all elbow extension, they can expect a functional range of movement in time. If there is a mechanical block to forearm rotation, then surgery may be advised to reduce the fragment and fix it to allow movement. More fragmented and displaced injuries may require surgical treatment, especially if there is associated elbow instability.

Olecranon fractures can be divided in to two broad categories: a simple transverse fracture that may occur as an avulsion due to a fall on to an outstretched hand with the triceps contracting, or a multifragmentary fracture which is due to a direct blow or a fall onto the elbow. The fracture always enters the elbow joint and therefore may damage the articular cartilage. With transverse fractures, the triceps aponeurosis sometimes remains intact, in which case the fracture fragments stay together. Swelling and bruising are usually evident. A breach of the skin indicates a direct blow to the elbow. A gap may be palpable and the patient will be unable to extend the elbow against resistance. An undisplaced transverse fracture that does not separate when the elbow is X-rayed in flexion can be treated without surgery. Casting is not recommended, but a sling can be used for comfort. Operative repair is recommended for displaced fractures and those with instability of the ulno-humeral or radio-capitellar joints. A plate and screws should be used in all cases except those with simple transverse fractures with a stable joint, in whom a suture repair or tension band wiring can be used. Immediate post-operative mobilisation is recommended. Stiffness used to be common, but with early mobilisation the residual loss of movement should be minimal. Non-union sometimes occurs after inadequate reduction and fixation – if elbow function is good, it can be ignored; if not, rigid internal fixation and bone grafting will be needed. Ulnar nerve symptoms can develop. These usually settle spontaneously. Osteoarthritis is a late complication, especially if reduction is less than perfect.

Fracture dislocation of the elbow

Elbow fracture dislocations occur as a result of forces applied through the forearm that acts as a long 'lever arm' to multiply forces across the elbow. These forces can be 'twisting' or rotational forces, bending forces or axial loads. The elbow will appear deformed if the it remains dislocated, but spontaneous reduction is common.

Lateral or external rotation injury (terrible triad)

Elbow dislocation with fracture of the radial head, coronoid process and medial collateral ligament rupture is known as

Figure 5: Fixation of a clavicular fracture with titanium plates.

a terrible triad injury. The injury is now well-understood and no longer earns the 'terrible' title, but as with other elbow injuries, stiffness is a common problem. The treatment is usually surgical with radial head fixation or replacement and lateral ligament repair. Coronoid fixation is only required if the fracture extends to the medial facet. Opinion varies about the need to repair the medial ligament.

Medial or internal rotation injury (posteromedial fracture dislocation)

This results in an isolated fracture of the anteromedial facet of the coronoid and lateral ligament complex. Often dismissed as a 'tip of coronoid' fracture, this injury pattern has only been recognised relatively recently. CT will identify the subtle coronoid fracture in a patient that typically reports a fall backwards on to the hand. In many cases non-operative management will result in rapid progression to osteoarthritis. Treatment consists of lateral ligament repair, with or without fixation of the coronoid fragment, depending on its size.

Proximal ulna fracture and dislocation of the radial head (Monteggia fracture dislocation)

Monteggia fracture dislocation is a proximal ulna fracture with dislocation of the radial head from the radiocapitellar joint. These can be divided into those with an apex anterior ulna fracture and those with an apex posterior ulna fracture. Apex

anterior fractures carry a better prognosis because the radial head is often intact. In apex posterior fractures, the radial head is driven in to the capitellum resulting in comminuted radial head fracture that may be associated with coronoid fracture and ligament injury.

Axial load

Axial loads through the forearm from a high energy fall on to the hand result in fracture of the radial head and proximal migration of the radius relative to the ulna. This rare injury is associated with rupture of the central condensation of the interosseous membrane of the forearm which should be addressed to produce a satisfactory outcome.

Complications

Joint stiffness is common and may involve both the elbow and the forearm. Even with minimally displaced fractures, the elbow can take several months to recover and stiffness may occur. Recurrent instability of the elbow may also be seen.

Simple dislocation of the elbow

Dislocation of the ulno-humeral joint is the second most common major joint dislocation after the shoulder. A simple dislocation is one without a fracture (flake avulsions at the ligament insertions may be seen). Injuries are usually classified according to the direction of displacement. In more than 90% of cases the forearm

dislocates in a posterior direction relative to the humerus. The majority of dislocations occur as a result of a fall on to an outstretched hand with the elbow in extension. Approximately 8% of cases will result in recurrent instability of the elbow. Simple dislocations may be associated with damage to surrounding nerves and blood vessels, especially if the injury is open – suggesting a more high-energy injury. The patient will present supporting the elbow in slight flexion. Unless swelling is severe the deformity is obvious. The bony landmarks (olecranon and epicondyles) may be palpable and abnormally placed. However, in severe injuries the pain and swelling are so marked that examination of the elbow is impossible. Nevertheless, the hand should be examined for signs of vascular or nerve damage. Treatment is by prompt reduction, which may require sedation. An assessment by an experienced upper limb surgeon is required to determine the need for surgical intervention to prevent recurrent dislocation. An MRI can assist this decision. If surgery is not required, or after stabilisation, the arm is held in a collar and cuff with the elbow flexed above 90 degrees. After 1 week the patient gently moves the elbow while lying supine with the shoulder flexed to 90 degrees and the forearm in neutral rotation. The collar and cuff are discarded when the patient is comfortable. Passive 'stretching' of the elbow is to be avoided. The long-term results are usually good.
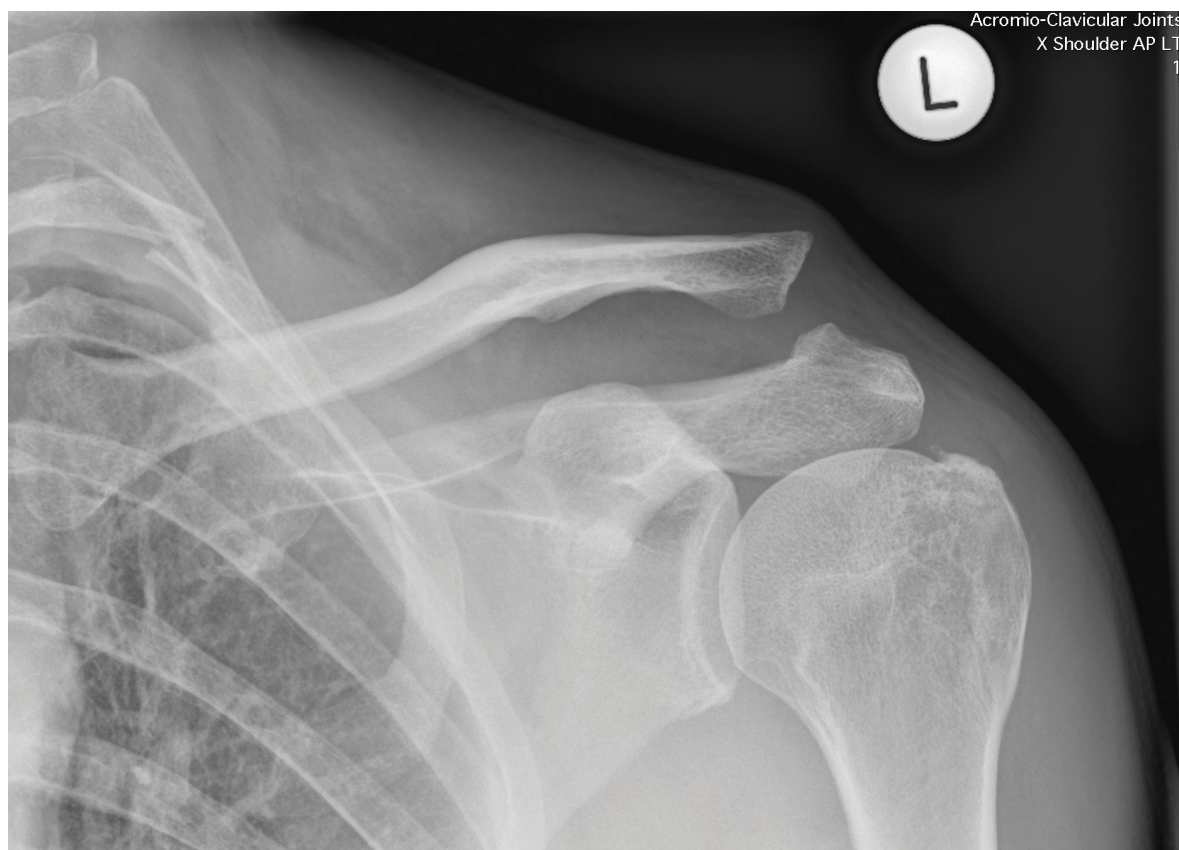
Acromio-Clavicular Joints
X Shoulder AP LT
1

L

Figure 6:
Acromioclavicular
joint separation.

SHOULDER

Shoulder injuries are common in cyclists, with the most common being acromioclavicular joint injuries, clavicle fractures, greater tuberosity fractures and traumatic rotator cuff tears. Again, current evidence regarding management of acute injuries needs to be balanced with the need of the athlete and the ultimate aim of returning to competitive sport as soon as possible.

> **Patholaxity can result from a single dislocation or repeated traumatic events**

Clavicle

These common cycling fractures occur following a direct fall onto the lateral aspect of the shoulder, falls onto an outstretched hand or direct trauma. Diagnosis is nearly always immediately apparent with obvious subcutaneous deformity. Diagnosis can be confirmed with anteroposterior and 30 degrees cephalad tilt radiographs. In the general population, the majority of clavicle fractures can be managed non-operatively using simple sling immobilisation for 2 to 4 weeks, then mobilising as pain allows, with return to sports at approximately 3 months. Indications for surgical fixation in the general population in isolated clavicle fractures include open fractures, those with shortening of more than 2 cm and high-energy injuries with comminution. Although non-operative management of clavicle fractures is a well-accepted treatment strategy in the general population, there is a non-union rate of up to 13% in these injuries[2] and elite and professional cyclists are unlikely to accept such a lengthy rehabilitation period. Titanium plates are mostly used nowadays, as there is less risk of peri-plate fracture and they generally do not require removal electively. One study of professional cyclists showed they returned to cycling following surgical fixation at around 3.8 weeks with evidence that they tend to return sooner than advised by their surgeon given the good pain relief that stabilisation provides[3].

Acromioclavicular joint

Acromioclavicular joint (ACJ) injuries occur following a fall onto the point of the shoulder in such a way that the scapula is forced inferiorly by the impact, relatively displacing the clavicle superiorly. As a result, the acromioclavicular and coracoclavicular ligaments are sequentially torn with damage to the ACJ itself and disruption to the deltopectoral fascia or trapezium. These injuries range from a simple 'sprain' of the ACJ ligament to complete separation of the ligament and displacement of the joint. Traditional classification systems are based on the pathology and judged radiologically. There is no level one evidence relating to treatment or outcomes of these. Most surgeons still use radiographs for classification including the Zanca view (15 degrees cephalad radiographs of the ACJ) for classification, often comparing the bilateral shoulder joint. However MRI may be more useful in determining the extent of soft tissue injury and this is being used

©Tim de Waele/Corbis/Getty Images
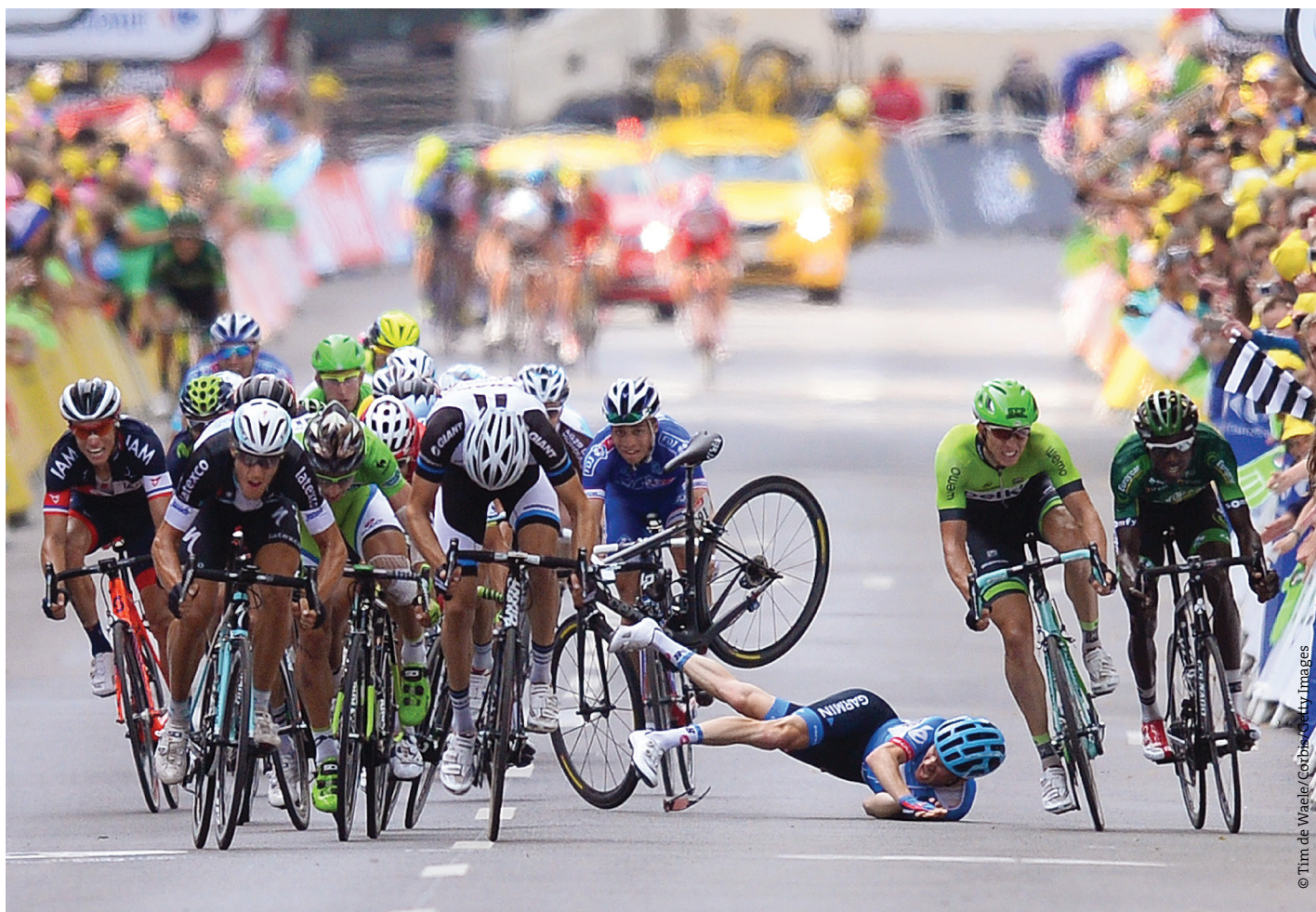
with increasing frequency. ACJ disruption is a difficult pathology to treat, with many patients remaining symptomatic at 6 months. In particular, overhead athletes and those involved in contact sports struggle to maintain high-level performance. In non-high-level overhead athletes there is little evidence to suggest which patients and which injuries benefit from surgery, with one review of the literature concluding that for grade 3 injuries "clinical results seem to be comparable between the operative and conservative treatments, but complications are more evident in the surgery group". Therefore, given the minimal overhead demands required in elite cyclists, the authors would not propose acute surgical fixation, given that the long-term outcomes appear to be similar with or without surgery and traditional techniques carry a not insignificant failure rate. In general, we would recommend a sling and early mobilisation as pain allows, with return to sports (non-contact) as able. A clinical review at 3 months to consider surgery should only be considered if the patient remains symptomatic.

Greater tuberosity fractures

Although greater tuberosity fractures are commonly associated with shoulder dislocations, they frequently occur in isolation, again in a fall directly onto the shoulder or onto an outstretched hand. While radiographs clearly define displaced fractures with or without associated dislocations, undisplaced fractures may not be apparent, requiring the need for further imaging in the form of MRI or ultrasound scan. A displaced greater tuberosity fracture is usually displaced posterosuperiorly due to the resulting unopposed action of the rotator cuff and if left untreated, may lead to impingement against the acromion if mal-union occurs. If associated with a dislocation, the majority of displaced fractures reduce following reduction of the humeral head. These are typically managed non-operatively in the general population but in elite, non-contact athletes who will not tolerate a period of immobilisation, surgical fixation is possible often via minimally invasive techniques, permitting early mobilisation and return to training.

Rotator cuff tears

Acute traumatic rotator cuff tear occurs frequently in shoulder trauma with or without dislocation, but are frequently underdiagnosed, possibly due to the lack of initial obvious radiological findings. Therefore a high index of suspicion is required in riders following a fall, even with normal radiographic findings, particularly in those patients with shoulder pain persistent for more than 1 week. A full clinical assessment of the rotator cuff should be made and any deficit or lag acted upon. Even without focal signs, any patient with persistent symptoms should be imaged with an ultrasound scan or MR arthrogram, as arthroscopic surgical repair in the acute phase is preferable.

Shoulder dislocations

Traumatic shoulder dislocations may occur in cyclists following a fall. Mechanisms can include a fall directly onto the shoulder itself or onto an outstretched hand. More than 90% are anterior dislocations with the majority being reduced by closed reduction techniques. Acute management

> > Acromioclavicular joint disruption is a difficult pathology to treat, with many patients remaining symptomatic at 6 months

of these injuries is straightforward in most cases, but dislocations are associated with several other pathologies including: neurological injury (13.5% clinically, up to 48% demonstrated with electromyography), greater tuberosity fractures (16%), rotator cuff tears, as well as Bankart's, Hill-Sach's and SLAP (superior labral tear from anterior to posterior) lesions. It is these associated injuries and the relative risk of future dislocations which leads to controversy in the long-term management, with multiple surgical techniques used depending on the pathology – it is beyond the scope of this article to describe these. If recurrent dislocations do occur, 90% occur within 2 years. There is an inverse association of recurrent dislocation with age, i.e. the older the patient the less likely a future dislocation, as well as level and types of sport, e.g. increased risk with contact/overhead sports. In those managed non-operatively, mobilisation can begin immediately as pain allows, with long-term slings or external rotation splints no longer advocated[6].

CONCLUSION

In summary, there are many and varied upper limb injuries which occur in the elite cyclist. Although many of these are immediately apparent and commonly well-managed, many are not and delayed management can lead to a poor prognosis and further time away from competition. While many of the injuries described have classically been managed non-operatively in the general population, the advancement in surgical techniques available combined with the increasing competitive and commercial pressures on the elite cyclist, has led to surgical management becoming more common. Although all types of surgery come with associated risks, these are frequently low and may bring advantages in rehabilitation times and return to competition, which often is the ultimate aim of the elite athlete.

References

1. Slane J, Timmerman M, Ploeg HL, Thelen DG. The influence of glove and hand position on pressure over the ulnahr nerve during cycling. Clin Biomech (Bristol, Avon). 2011; 26:642-648.

2. Murray IR, Foster CJ, Eros A, Robinson CM. Risk factors for nonunion After nonoperative treatment of displaced midshaft fractures of the clavicle. J Bone Joint Surg Am 2013; 95:1153-1158.

3. Taylor F, Watts A, Walton M, Funk L. Return to Biking following clavicle fracture fixation. Presented at Wrightington Gold Medal Research Day 2013, Wigan, UK.

4. Ceccarelli E, Bondì R, Alviti F, Garofalo R, Miulli F, Padua R. Treatment of acute grade III acromioclavicular dislocation: a lack of evidence. J Orthop Traumatol 2008; 9:105-108.

5. Krøner K, Lind T, Jensen J. The epidemiology of shoulder dislocations. Arch Orthop Trauma Surg 1989; 108:288-290.

6. Brownson P, Donaldson O, Fox M, Rees J, Rangan A, Jaggi A et al. BESS/BOA Patient Care Pathways: traumatic anterior shoulder instability. Shoulder Elbow 2015; 7:214-226.

Richard Knight M.B.Ch.B., F.R.C.S.
Upper Limb fellow

Len Funk M.B.Ch.B., B.Sc. (Sports Physiol), M.Sc. (Engin), F.R.C.S. (Tr & Orth), F.F.S.E.M.
Consultant Shoulder Surgeon

Adam Watts M.B.B.S., B.Sc., F.R.C.S. (Tr & Orth)
Consultant Elbow Surgeon

Mike Hayton M.B.Ch.B., B.Sc. (Hons), F.R.C.S. (Tr & Orth), F.F.S.E.M.
Consultant Hand and Wrist Surgeon

Wrightington Hospital
Wigan, United Kingdom
Contact: Richard.knight4@nhs.net