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Review article

Lateral elbow instability

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Abstract

Lateral elbow stability utilises a combination of bony and soft tissue constraints. Lateral elbow instability is usually associated with an episode of elbow dislocation. Isolated lateral ligament complex insufficiency results in posterolateral rotatory instability (PLRI), The most common presentation is lateral elbow discomfort and a sensation of instability, without recurrent dislocation. The lateral pivot shift test is unreliable for diagnosing PLRI when the patient is awake due to significant apprehension. Stress radiographs, fluoroscopy, computed tomography and arthroscopy are all useful investigations to confirm the diagnosis of lateral instability. Surgical treatment is indicated for functional instability. All associated fractures need to be addressed. In severe cases, the medial structures and the posterolateral capsule may also require reconstruction.

Keywords: Elbow instability; Elbow dislocation; Ligament reconstruction; Posterolateral rotatory instability

Introduction

Simple elbow dislocation is relatively common, accounting for 11−28% of all elbow injuries.[1] The most common direction of instability is posterior and postero-radial.[2] The majority of patients have good results from closed reduction and non operative management, but up to 35% will have recurrent lateral elbow instability symptoms.[1,3] This recurrent instability can be a debilitating problem for the patient.[4]

This article will describe: (1) the relevant anatomy of the stabilising structures about the elbow, (2) the pathological processes involved in acute and recurrent lateral elbow instability, (3) the common presentation of patients with this condition, (4) the relevant investigations required to confirm the diagnosis and (5) treatment options.

Anatomy

The inherent stability of the elbow relies on a combination of bony articulations and soft tissue restraints. There are three separate articulations in the elbow joint: the ulnotrochlear, radiocapitellar and proximal radioulnar joints.[5] The soft tissue restraints consist of joint capsule, the collateral ligaments and the musculotendinous complexes that span the elbow joint.

Coronoid

The coronoid is the most important stabiliser to anterior and posterior translation. It forms a buttress against posterior dislocation of the ulna on the humerus and it is the attachment point of the anterior MCL band, the middle third of the anterior capsule and the deep head of the brachialis.

Lateral collateral ligament

The lateral collateral ligament (LCL) complex arises from the lateral epicondyle at the isometric point of the elbow. The

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complex had four components: the lateral ulnar collateral ligament (LUCL), the lateral radial collateral ligament (LRCL), the accessory lateral collateral ligament and the annular ligament. (Fig. 1). The LUCL inserts on tubercle of the supinator crest of the ulna. It is the primary restraint to ulna supination on the humerus. The LRCL inserts into the annular ligament, stabilising that ligament and providing varus restraint.

Medial collateral ligament

The medial collateral ligament (MCL) complex has three components: the anterior, the posterior and transverse bands. The anterior and posterior bands arise from the anterior-inferior aspect of the medial epicondyle. The anterior band inserts onto the sublime tubercule into the anteromedial aspect of the coronoid process and the posterior band into the medial margin of the greater sigmoid notch. The anterior band is the most important restraint to elbow valgus and the posterior band is the primary restraint to pronation of the ulna on the humerus.[6] The transverse bundle does not have a role in elbow stability.[7]

Elbow stability

The structures that stabilise the elbow can be classified as primary, secondary and dynamic stabilisers. The *primary stabilisers* include the ulnotrochlear articulation, MCL complex and LCL complex.[8] The *secondary stabilisers* augment stability and become particularly important when there is insufficiency of the primary stabilisers. They are the radiocapitellar articulation, the anterior and posterior capsule and the common flexor and extensor muscle origins. In addition there are *dynamic stabilisers* consisting of the brachialis, anconeus, biceps and triceps muscles.[8]

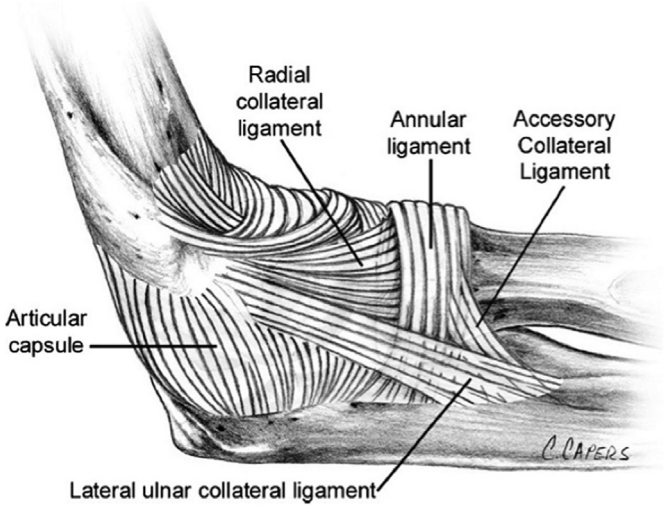

Fig. 1. Lateral collateral ligament complex. Figure used with permission from Bain GI, Mehta JA. Anatomy of the elbow joint and surgical approaches. In: Baker CL Jr, Plancher KD, eds. *Operative Treatment of Elbow Injuries.* New York, NY: Springer-Verlag;2001:1–27.

The anconeus and the deep head of brachialis span the lateral aspect of the elbow joint, parallel to the lateral ulnar collateral ligament (LUCL). The anconeus is posterior to the lateral epicondyle and the deep head of brachialis is anterior. This dynamic muscular sling helps protect the LUCL when subjected to a forced supination of the ulna on the humerus.[9]

Pathoanatomy

Osborne and Cotterill[10] described the mechanism of injury and pathoanatomy of both simple and recurrent elbow dislocation in 1966. They reported that the lateral ligament is stripped superiorly and the posterolateral capsule is torn, allowing the head to rotate posteriorly from the Capitellar surface. The essential defect in recurrent instability was the failure of the lateral structures to become reattached to the humerus.[10]

O'Driscoll et al. proposed that in an elbow dislocation, there is a three-stage sequence of soft tissue disruption,[11] also referred to as the Circle of Horii.[12] Disruption of the LCL complex (particularly the LUCL) results in posterolateral rotatory subluxation of the elbow. As the injury progresses, the anterior and posterior capsules are disrupted, then finally the MCL is ruptured. When the lateral and medial soft tissues are disrupted, the joint can dislocate even with immobilization of the elbow in 90° of flexion.

Although a dislocation usually involves injury to both medial and lateral structures, residual instability is more common on the lateral side. Most activities of daily living place a varus stress across the elbow, which stresses the lateral structures.[4]

To manage lateral elbow instability effectively, the surgeon must be aware of the pattern of instability and the structures that are likely to be deficient. Elbow instability can be classified according to the direction of the instability episode and the associated injury to the different stabilising components.

Posterolateral rotatory instability (PLRI)

This is the most common pattern of instability. When the LCL complex fails, it avulses as a sheet along with the capsule and the common extensor origin on the humerus. With persistent subluxation of the joint it displaces distally to lie over the articular surface of the capitellum, to which it is unable to heal.[13] The loss of this restraint allows the radial head to subluxate posteriorly on the capitellum.

In O'Driscoll et al.'s[14] classical description of PLRI, the LUCL was the key structure responsible for maintaining stability. However, this model has since been called into question. Recent literature has suggested that the components of the lateral ligament complex act in combination to prevent PLRI, rather than the LUCL acting in isolation.[15]

Varus instability

This occurs when the LCL is disrupted, either after an acute dislocation or in a chronic case where the ligament complex

has not healed. The normal anatomic alignment of the elbow is in valgus, which can mask the symptoms of this instability pattern. Varus instability may be symptomatic in patients that use their upper limbs as weight-bearing extremities, e.g., those that rely on crutches.[16] The lateral ligament avulsion may be associated with a medial coronoid process fracture. This combination is commonly referred to as posteromedial rotatory instability.[17]

Iatrogenic instability

Previous surgery, including lateral epicondyle release and radial head excision, as well as repeated steroid injections to the lateral epicondyle have all been shown to cause iatrogenic LCL incompetence.[4,14,18]

Clinical presentation

History

The patient may volunteer an episode of traumatic instability, but their main complaint may be pain, mechanical symptoms or a decreased level of performance in sporting activities.

In PLRI, the patients may present with recurrent elbow dislocations, with each subsequent dislocation requiring less force. However, recurrent painful clicking, snapping, clunking, or locking of the elbow are the most common symptoms, and these usually occur in the extension half of the arc of motion with the forearm in supination.[19]

All prior treatments to the affected elbow must be noted (e.g., bracing, therapy, surgery). The patient's age, hand dominance, occupation and expectations of outcome are all important factors to document as they help guide the ideal treatment for the individual patient. Any medical comorbidities that might preclude surgery must also be identified.

Examination

Bruising and swelling on the medial or lateral aspect of the elbow suggests an acute injury to the underlying structures. Tenderness to palpation will further suggest injury. The range of movement of the elbow is documented and then the integrity of both the medial and lateral ligament complexes is assessed. Crepitus during movement is suggestive of an osteochondral fragment or fracture. A neurovascular examination must also be performed.

Posterolateral rotational instability

These patients normally have a pain-free elbow with a full range of motion. Often the only abnormality in the examination is a positive lateral pivot shift test.[14] The patient will have apprehension when performing this manoeuvre, which may mask the instability and makes assessment difficult.

Two other described tests for PLRI are both active apprehension signs.[20] The first involves the patient performing a floor push up with the elbow fully supinated and the second test has the patient push up on the arms of a chair to stand, again with the elbow fully supinated. In both tests a subjective feeling of apprehension, instability or frank dislocation is considered positive for PLRI. Regan and Lapner[20] reported on the usefulness of these two signs in eight patients with PLRI. All eight had positive results for both apprehension signs, whilst only three had a positive awake pivot shift test.

Investigations

Plain radiographs

An anterior-posterior (AP) view and a true lateral view should be obtained on every patient. The congruency of the joint is noted and any associated fractures must be identified. Lateral ligament laxity can be identified on the true lateral view from the "tilt sign",[21] which is a subtle widening of the trochlea/trochlear notch interval.

Fluoroscopy

Fluoroscopy is a very useful tool to assess elbow instability. It allows the surgeon to observe any joint space widening in real time, whilst a varus or valgus force is applied to the elbow.

Computed tomography and magnetic resonance imaging

Three-dimensional CT scanning is of value in complex cases to assess fractures and intra-articular fragments. MRI may help to identify ligamentous and cartilaginous injuries.

Arthroscopy

An arthroscopic evaluation of the ulnohumeral joint can demonstrate joint space widening during varus/valgus and rotational stresses.[22] Assessment of associated intra-articular injuries and of the severity of the instability can also be performed with the arthroscope, as well as débridement. The sleeve of lateral ligament complex that is usually torn off the lateral epicondyle can be seen through the proximal anteromedial viewing portal as a rent in the lateral ligament complex. This is the best sign of PLRI that can be seen in the anterior compartment. PLRI is otherwise difficult to identify in the anterior compartment because the radial head slides posteriorly off the capitellum, which can make it impossible to assess whether this is normal or pathological because the radiocapitellar joint appears to close.[21] The anteromedial portal can also be used to observe any osteochondral injuries to the radiocapitellar articulation.

The proximal anterolateral portal is used to demonstrate the coronoid-trochlea articulation. Widening of >1 mm during varus or valgus stressing is abnormal.[21]

The posterior compartment is the best region to assess rotatory instability. In a normal elbow the olecranon− trochlea articulation will open enough to allow a probe medially and laterally. In PLRI the arthroscope can be introduced between the trochlea and trochlear notch. The bare area of the

olecranon, radial head and a rent in the lateral capsule can often be seen.[21]

The authors use arthroscopy to classify patients with PLRI into three groups.

1. Isolated PLRI, which requires a lateral repair or reconstruction.
2. PLRI combined with medial instability, which requires a global reconstruction.
3. PLRI joint degeneration, which needs consideration of the joint stability and its articular surface.

Treatment

Simple posterior elbow dislocations

After closed reduction has been performed the elbow is examined and plain radiographs are taken. If the elbow is stable through the full range of motion and a congruent reduction is seen radiologically, the patient is given a broad arm sling for comfort and is encouraged to mobilize the elbow. Physiotherapy is not usually necessary.[13]

If the elbow subluxes or dislocates in extension, the stability should be reassessed with the forearm in pronation. If this restores stability, a hinged brace is applied with an extension block and the forearm being maintained in full pronation.[8] If the elbow is more stable in supination, then the injury is confined to the MCL complex.[23] Surgical repair of the ligaments should be considered if more than 30–45° of flexion is required to maintain reduction.[8]

Overall, surgery is seldom necessary in the management of a simple posterior dislocation.[23] The indications for surgery include failure to obtain and maintain a congruent reduction, persistent instability of the elbow joint requiring immobilization beyond 30–45° of flexion, and suspected entrapment of intra-articular fragments or the median nerve in the joint. The primary goal of surgical treatment is to achieve stability to allow early range of motion.

Posterolateral rotatory instability

The indication for surgery in PLRI is symptomatic instability.

Approach

The patient is placed in the lateral decubitus position with the arm over a bolster. A global approach allows access to medial and lateral structures and is the authors' preferred approach.[24] A posterior midline incision is made and full thickness fasciocutaneous flaps are elevated. A deep window is made through the Kocher interval between anconeus and extensor carpi ulnaris. The anconeus is reflected to exposing the remnants of the LCL complex. A "bare area" is commonly seen on the lateral epicondyle where the lateral ligamentous complex has avulsed off.

Lateral ligament repair

A repair is performed in the acute setting. The authors' preferred technique is an anatomical repair using grasping sutures and tensionable suture anchors. These have the advantage of allowing controlled, sequential tensioning of the ligmanents, with the ability to cycle the elbow and check the balance and stability before final tensioning.[25]

All grasping sutures should be passed and the anchors placed, but unlocked, before the sutures are tensioned. The authors call this "pre-fabrication". If both the MCL and LCL are being repaired then the MCL is tensioned first, with the elbow flexed and the forearm supinated. The LCL is then tensioned in pronation.

Lateral ligament reconstruction

The indication for ligament reconstruction is insufficient ligamentous tissue for a repair. These are usually patients with chronic recurrent instability. The reconstruction should be isometric, extracapsular and anatomical, using an autogenous graft.[26] There are many graft choices and techniques described, including advancement and imbrication of the LCL, autologous palmaris longus tendon, a strip of the triceps tendon, plantaris tendon and synthetic material.[8,26–28]

The authors' preference is to use an autogenous hamstring graft, which is more robust than palmaris longus tendon and reliably gives the required length (15–20 cm) needed for the technique. Autogenous graft is preferred over synthetic grafts.

Two separate transverse 4.5 mm drill holes are made in the ulna at the insertion point of the LUCL—one just proximal and one just distal to the supinator crest. These are extra articular holes, just distal to the capsular attachment. Two holes are then drilled in the distal humerus. Both start at the same point on the lateral epicondyle at the isometric point of the elbow. One hole is directed from anterior to posterosuperior, the second in a posteroinferior direction, ensuring that there is an adequate bone bridge between the holes. The graft is passed through the common hole, out of the inferior hole, into the more superior hole and back out of the common hole. This forms a loop around the posterior aspect of the lateral epicondyle. The graft ends are then delivered through the ulna tunnels, from lateral to medial. The construct is tensioned and then secured with interference screws.

Global instability

Global instability is the presence of both medial and lateral instability. The authors have developed a circumferential graft technique that utilises a single tendon graft to address both the medial and lateral instability.[29] This technique may also be used to address any residual instability following fixation of fractures associated with complex fracture dislocations or terrible-triad injuries. When fracture fixation and ligament repair have failed to restore elbow stability, this reconstruction can be used as an alternative to dynamic external fixation.[29]

A single-loop technique will reconstruct the anterior band of the MCL and the LUCL, or in more severe instability cases it may be performed as a double-loop technique, which

reconstructs all four ligamentous units (LUCL, posterolateral capsule, anterior and posterior bands of the MCL) (Fig. 2).

Single loop technique

A 4.5 mm drill is passed through the humerus along the axis of rotation (i.e. between the lateral epicondyle and the antero-inferior aspect of the medial epicondyle). In the ulna a 4.5 mm drill is passed from the sublime tubercle (medial side) to the supinator crest (lateral side). A hamstring tendon graft is passed through the humeral drill hole and secured with an interference fit screw at each end. The two tendon ends are passed through the ulna hole from either side and secured with inference fit screws. The flexor-pronator mass is repaired back to the medial epicondyle, and the Kocher interval is closed.

Double loop technique

This is similar to the single loop technique but also reconstructs the posterior band of the MCL and the posterolateral capsule. This is accomplished by placing a second ulna drill hole from the supinator crest laterally to the postero-medial olecranon facet at the attachment of the posterior band of the MCL.

Once the hamstring graft has been passed through the humeral drill hole, the free ends of the graft exiting the humerus are split longitudinally to create two free tails of equal size on each side. One tail from each side is passed through each of the two drill holes in the ulna. The graft is tensioned and secured with interference fit screws in the humerus and then the ulna. The elbow must be fully reduced throughout this procedure, particularly before the graft is secured.

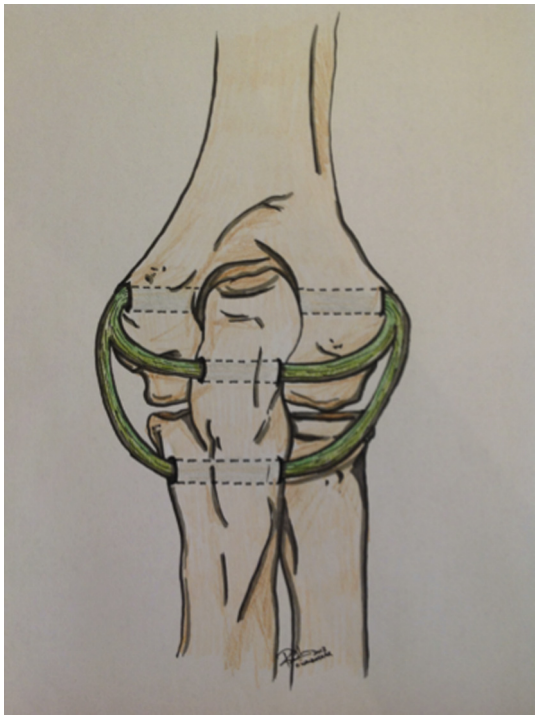

Fig. 2. Anteroposterior view of the elbow demonstrating the double loop circumferential graft reconstruction. Figure used with permission from McGuire G, Bain GI. Medial and lateral collateral ligament repair or reconstruction of the elbow. *Oper Tech Orthop*. 2013;23:205–214.

Coronoid process fractures

The coronoid process is the most important anterior stabilizer of the elbow. It is a buttress against anterior translation and resists rotatory translation of the trochlea during range of motion of the elbow.[30] Fractures of the coronoid at the time of elbow dislocation are associated with both lateral and medial instability syndromes. The "terrible triad" injury of the elbow involves dislocation, a coronoid fracture and a radial head fracture. If there is an impacted anteromedial coronoid process fracture and the radial head is not fractured it can be part of posteromedial varus rotatory instability.[17]

Acute fractures

The indications for fixation of coronoid process fractures are an acute dislocation with either a type II (up to 50%) or type III (>50%) fracture of the process,[31] or an impacted medial coronoid fracture.

There are many described coronoid process fixation techniques that have been described. The authors' preferred option is to use an anterior buttress plate, using an anterior incision and a brachialis splitting approach to expose the coronoid process. A K-wire is used to provisionally fix the fragment and then a 2.0 mm variable angle locking T-plate is slid over the wire. The variable angled screws can be angled away from the articular surface. (Fig. 3A, B and C)

Chronic injuries

In the setting of chronic dislocations and secondary surgery, comminution, malunion and bone loss may make the coronoid fracture irreparable.[30] In this situation an osteochondral graft may be required. There are many potential sources of graft including discarded radial head, ipsilateral olecranon tip, iliac crest and allograft.[30,32,33] The effectiveness of prosthetic coronoids in restoring elbow stability has also been assessed in a cadaveric model.[34]

The authors have described a coronoid reconstruction technique using an osteochondral rib graft.[35] The graft is obtained from the sixth costal cartilage, which has bone to heal onto the ulna and hyaline cartilage for articulation with the trochlea. The osseous portion of the graft is seated into a trough that has been fashioned in the anterior ulna. A press fit is obtained and the construct is then fixed with an anterior buttress plate. (Fig. 4) The graft is positioned to allow the cartilaginous part to make a smooth continuous articular surface with the remaining native surface, without causing impingement in maximum flexion. This may required some sculpting of the graft cartilage.

External fixation

External fixation has been used for elbow instability. The authors now only have three indications for this:

1. Acute injuries with bone or soft tissue loss, e.g., open dislocation with loss of lateral condyle

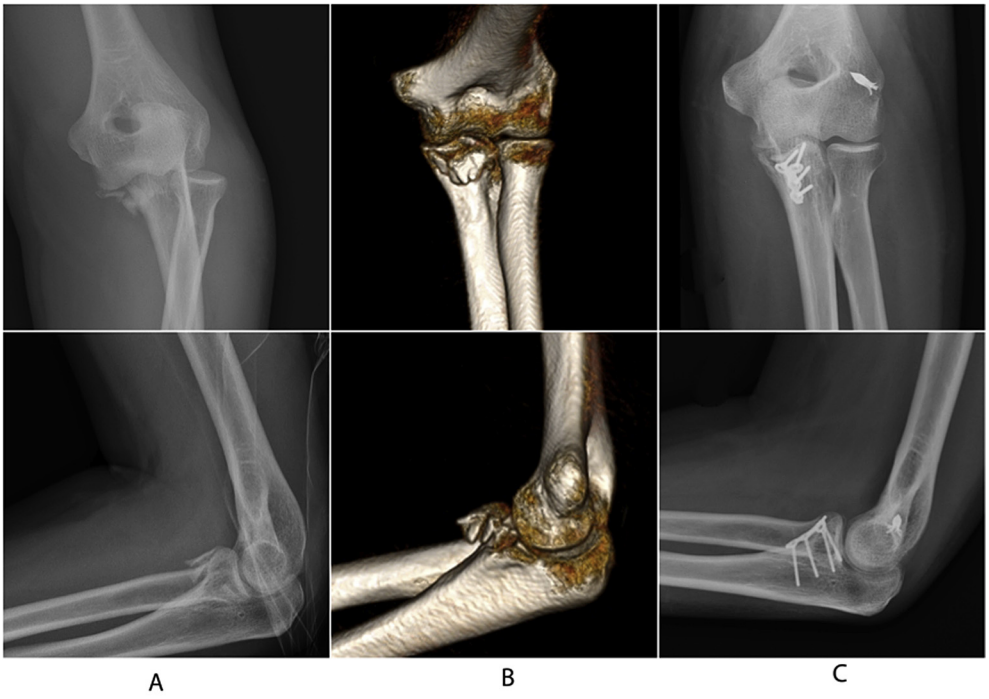

Fig. 3. Radiographs (A) and CT scans (B) of a comminuted coronoid fracture. Fixation with an anterior buttress plate and screws (C). Figure used with permission from McGuire G, Bain GI. Medial and lateral collateral ligament repair or reconstruction of the elbow. *Oper Tech Orthop*. 2013;23:205−214.

2. Complex osseo-ligamentous reconstructions where a neutralization device is required until osseous and soft tissue healing has occurred.
3. Interposition arthroplasty when we utilize the anterior capsule as an interposition graft that is sutured to the distal humerus. A reconstruction using a circumferential hamstring tendon graft is performed, and then a dynamic external fixator is applied as a neutralization device.

Outcomes

There are very few large studies that report outcomes of lateral elbow instability. In general the results of lateral ligament surgery have shown good to excellent outcome scores and few complications. Elbow discomfort and recurrent instability are the most common complications.

Sanchez-Sotelo et al.[27] reported 44 cases of lateral ligament repair or reconstruction at a mean follow-up of 6 years. The mean Mayo Elbow Performance score was 85, and seven patients (16%) experienced one or more recurrent instability episodes in the same elbow. In five of those cases, there was no episode of trauma associated with the recurrent instability. Better results were seen in cases of instability due to traumatic aetiology and in patients with subjective instability at the time of initial presentation.[27]

Lee & Teo[36] reported 10 reconstructions at a mean 24 months' follow-up. Six patients were pain free and four had

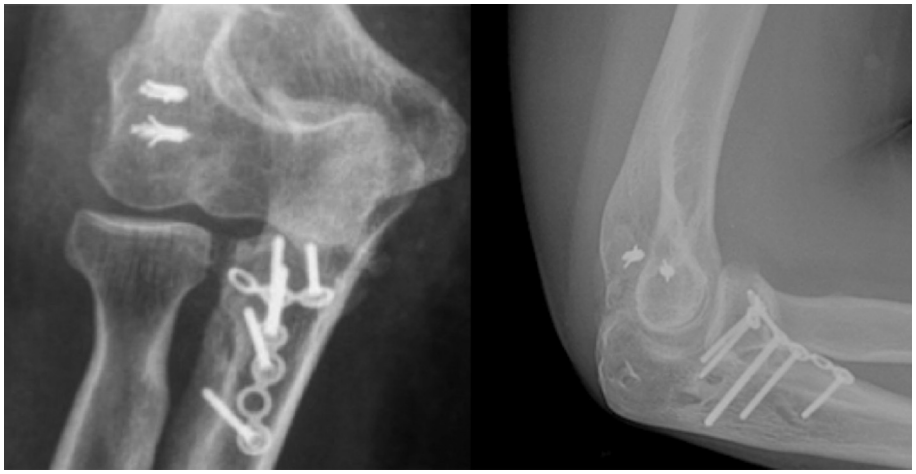

Fig. 4. Anteroposterior and lateral views of coronoid augmentation using a rib osteochondral autograft. LCL reconstruction had been performed using tensionable bone anchors. Figure used with permission from McGuire G, Bain GI. Medial and lateral collateral ligament repair or reconstruction of the elbow. *Oper Tech Orthop*. 2013;23:205−214.

mild tenderness over the lateral epicondyle. None had any recurrent instability.

Kim et al.[37] reported 19 acute repairs at a mean 6.6 months' follow-up. The mean Mayo Elbow Performance Score was 86.9, and there were no cases of recurrent instability. Five cases showed asymptomatic ectopic ossification on X-ray; none of these required treatment.

Lin et al.[38] reported 14 reconstructions performed for PLRI at a mean follow-up of 49 months. Nine of the 14 (64%) were pain-free and the remainder had mild lateral elbow pain. None had recurrent instability. The Mayo Elbow Performance Score was 100 in 9 of 11 patients who presented with grade 1 or 2 instability, compared to 65−85 in patients presenting with stage 3 instability.

Conclusion

Lateral elbow instability is a spectrum of injury that may involve bony as well as soft tissue stabilisers. Medial structures may, potentially, be involved.

The surgeon must be alert to the diagnosis in a patient with persistent mechanical symptoms following an injury, even in the absence of frank instability episodes. Dynamic fluoroscopy and arthroscopy provide a large amount of information to the surgeon to aid diagnosis and treatment of recurrent instability.

Symptomatic recurrent instability requires surgical management of deficient bony and soft tissue structures. The decision to repair or reconstruct the lateral ligament complex depends on the integrity of the remaining soft tissues. In cases with associated laxity of the medial collateral ligament complex the surgeon must be prepared to perform a circumferential reconstruction to restore adequate stability.

Patients can expect good results and a low recurrence rate after lateral ligament surgery, with the most common symptom being mild residual lateral elbow pain.

Conflicts of interest

The authors declare that they have no financial or non-financial conflicts of interest related to the subject matter or materials discussed in the manuscript.

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