INTRODUCTION

This chapter will present two specific conditions of the elbow: elbow instability and arthritic conditions. Each section presents a short introduction with incidence/prevalence, relevant anatomy, clinical examination information and, finally, non-operative treatment. The reader is encouraged to remember that elbow dysfunction rarely occurs in isolation (Royle 1991, Walker-Bone et al. 2004). When approaching a clinical case involving elbow pathology, the clinician must determine the underlying primary aetiology, the potential secondary aetiologies, the associated impairments and finally the role of regional interdependence for determination of the appropriate plan of care.

ELBOW INSTABILITY

Overall, the elbow is the second most common dislocated joint in adults, with posterior dislocation being the most common (Royle 1991). It is the most commonly dislocated joint in the paediatric age group (Kuhn & Ross 2008). In the young or with advanced age associated injuries such as fractures occur, while non-complex dislocations most commonly occur within the younger, athletic populations (Mehta & Bain 2004). There are five criteria (O’Driscoll et al. 2001a) to assist in classifying elbow instability:
• the involved articulation(s)
• the direction of displacement
• the degree of displacement
• the duration (acute, chronic or recurrent)
• the presence/absence of associated fractures.

Injury progression is represented through the circle of Horii where the injury progresses from lateral to medial through soft tissue, bone or both. Due to the energy absorption by a fracture, one may see ligament sparing with a fracture of the radius or the coronoid. In the progression of stages, stage I would demonstrate disruption of the lateral collateral ligament (LCL) with a presentation of postero-lateral instability; stage II signifies disruption of the capsule with anterior and posterior instability and stage III demonstrates disruption of the portions of the medial collateral ligament. Stage III is further divided into subparts A, B and C (O’Driscol et al 2001a).

Anatomy review for elbow instability

There are three primary constraints for elbow stability: the ulno-humeral joint, the medial collateral ligament and the lateral ulnar collateral ligament. Though O’Driscol (2000) originally named the lateral ulnar collateral ligament as a primary constraint, there is controversy regarding its importance. Cadaver studies have demonstrated elbow posterolateral rotatory instability (PLRI) when artificially induced sectioning at various parts throughout the LCL complex (Olsen et al 1996, Singleton & Conway 2004). Secondary constraints include: the radial head, the common flexor origin, the common extensor origin, and the joint capsule. Dynamic constraints produce compressive forces at the joint including the biceps brachii, triceps, and anconeus (O’Driscol 2000).

General treatment planning guidelines for elbow instability

Treatment varies according to the severity of the injury. With an acute dislocation without an associated elbow fracture, the treatment recommended is a closed reduction followed by bracing for a short period of time. The patient is typically directed to use the upper extremity for daily function within symptom tolerance following weaning of the brace. Simple elbow dislocations have a good prognosis with up to 95% of the persons affected returning to their previous level of activity (Hildebrand et al 1999). However, if symptoms persist, then the intervention plan must be adapted dependent upon the injury and the symptoms reported. The presence of fractures with a dislocation/subluxation changes the course of treatment as typically there is surgical intervention for the fracture. If an acute ligament injury is sustained in conjunction with a fracture of the radius or the coronoid, then a repair of that ligament is necessary to assist with the stability of the joint (O’Driscol et al 2001a). In the sections which follow, elbow instability is further discussed by injury to the lateral or medial ligament structures.

Lateral elbow instability

Anatomy review for lateral elbow instability

The lateral collateral ligament (LCL) complex originates from the humerus at the trochlea and capitellum and continues distally to blend with the annular ligament inserting at the proximal ulna (Cohen & Bruno 2001). This complex consists of up to four structures: the annular ligament, the ulnar portion of the LCL, the radial portion of the LCL and the inconsistently present accessory LCL. The lateral ligament complex is taut throughout elbow flexion and extension. Ligament tension is increased with the forearm positioned in supination.

Incidence/prevalence of lateral elbow instability

Postero-lateral rotatory elbow instability (PLRI), an injury to the lateral collateral ligament and the soft tissue stabilizers, is the most common type of chronic instability at the elbow. In contrast, isolated varus instability from the laxity of the LCL is not as common as an isolated medial collateral ligament injury (Charalambous & Stanley 2008).

Pathology/patho-anatomy of lateral elbow instability

There are three typical scenarios that may lead to lateral collateral ligament injury: elbow dislocation, varus stress insufficiency/chronic attenuation or iatrogenic causes (Singleton & Conway 2004). Typically, elbow dislocation is an acute occurrence, O’Driscol et al. (1992) proposed that elbow posterolateral rotatory instability (PLRI) may be the initial step towards elbow laxity. PLRI may present as an independent pathology or it may be part of a continuum leading to dislocation (Smith et al 2001). PLRI has also been cited as the most common cause of recurrent symptoms following dislocation (O’Driscol et al 2001a). Chronic attenuation and/or varus insufficiency may occur with overuse such as in the cases of patients with significant weight bearing activities on the upper extremities such as crust ambulation or those persons with generalized ligament laxity. A causal relationship of cubitus varus and recurrent elbow instability in the form of PLRI has been reported by several authors, with symptoms which may not appear until more than two decades post injury (O’Driscol et al 2001a,b, Arrigoni & Kamineni 2009). It has been theorized that these symptoms may be
secondary to the attenuation of the ligament from the repetitive torque on the LCL and the inappropriate pull of secondary stabilizers. Iatrogenic cause to the integrity of the LCL may be from surgical approaches which involve the lateral elbow structures such as a lateral epicondylar release procedure or an approach to access the radial head (O’Driscoll 2000). Surgical approaches at the lateral elbow structures or to access the radial head may endanger the integrity of the LCL (O’Driscoll 2000).

PLRI affects the articulation between the ulna and the humerus while the proximal radio-ulnar joint remains intact. This differs from a simple posterior dislocation of the radial head where the ulno-humeral joint remains intact and the proximal radio-ulnar joint is disrupted. With postero lateral rotatory instability (PLRI), the forearm externally rotates (supinates) away from the humerus, effectively ‘pivoting’ on the intact medial collateral ligaments allowing the radial head to subluxate in a posterior direction.

These mechanics provide support for special attention to the position of the forearm during orthopaedic testing. Traditionally, varus stress testing is utilized when examining a patient with probable disruption of the lateral ligaments of the elbow. Valgus stress testing is to determine the laxity of the medial collateral ligament. Indications of probable medial collateral ligament laxity would be the presence of laxity/apprehension with the forearm in pronation and application of a valgus stress. The pronated forearm position and medially directed stress tensions the medial collateral ligament. During forearm pronation, the lateral structures of the elbow are tensioned, stabilizing the radial head. However, if the forearm is positioned in supination and a valgus stress is applied, the lateral structures are unable to appropriately stabilize the radial head. Therefore, if the patient demonstrates laxity or appears apprehensive when the forearm is supinated and tensioned in the valgus direction, PLRI should be suspected (Smith et al 2001).

**Diagnosis of lateral elbow instability**

In a search for lateral collateral laxity, history taking should include inquiring about the three potential mechanisms including both acute dislocations and a history of dislocation if a patient report is suspicious for chronic recurring instability. Questioning should include positions of the upper extremity that place the elbow at risk of chronic attenuation including history of elbow fracture as a youth. Additionally, medical history which may contribute to generalized ligament laxity should be explored.

Patient concerns may include ‘vague’ aching about the elbow joint, pain, clicking, snapping or clunking that is worse with a supinated position of the forearm. Patients may comment of ‘something not right’ when extending their arm with the forearm in supination (Lee & Rosenwasser 1999, O’Driscoll 2000). Unless there is an associated traumatic event, rarely will the patient be able to isolate the onset of the symptoms.

Physical exam measures include observation for a cubitus varus deformity, range of motion and special orthopaedic testing (Table 24.1) that may be passive and/or active. Reporting of the statistical evidence for orthopaedic tests is limited and due to the supportive roles of the secondary soft tissue constraints, the passive exam techniques are

**Table 24.1 Orthopaedic examination techniques for lateral elbow instability**

<table>
<thead>
<tr>
<th>Name of test</th>
<th>Physical exam technique</th>
<th>Outcome to indicate a positive test for pathology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varus stress test</td>
<td>Application of a laterally directed force applied in both full extension and at approximately 30° of elbow flexion to allow the olecranon to move out of the olecranon fossa. It is recommended to perform this test with the humerus fully internally rotated (O’Driscoll et al 2001b)</td>
<td>Greater laxity is felt by therapist in comparison to contralateral side.</td>
</tr>
<tr>
<td>Lateral pivot shift test</td>
<td>Patient lies supine with the shoulder passively flexed past 90°. With the elbow in extension, the examiner applies axial compression through the ulna and radius towards the humerus with a supination and valgus force causing the elbow to subluxate at ~40–70° of elbow flexion. If the patient allows the passive examination to continue, then an observable clunk occurs with continued flexion as the elbow reduces (O’Driscoll et al 1991, 1992, O’Driscoll, 2000)</td>
<td>Postero-lateral displacement of radius occurs followed by reduction as elbow flexion progresses to 90° (O’Driscoll et al 1991) The apprehension test would have the patient report apprehension prior to the subluxation.</td>
</tr>
</tbody>
</table>
often recommended to be completed with the patient under anaesthesia for best results (O’Driscoll et al 2001b). In the case of a varus directed stress test, a false negative may be reported as the ulno-humeral articulation is the main constraint to varus movements (Charalambous & Stanley 2008). As indicated earlier, the examination technique for medial collateral laxity via the valgus stress test may give the examiner clues to a potential PLRI pathology if completed with the forearm in supination (Olsen et al 1998). However, for detection of PLRI the most utilized examination technique is the postero-lateral rotatory instability test. Changing the positive response of the postero-lateral rotatory instability test to be patient apprehension instead of a visible ‘clunk’ has also been advocated (Charalambous & Stanley 2008). Suggested imaging includes: stress radiographs, arthrogram or for PLRI, MRI imaging can be used though a specific pulse sequence is described (Potter et al 1997).

In general, non-operative care for patients who demonstrate symptom producing recurrent instability such as that found with PLRI or varus insufficiency is not common. However; bracing to assist in avoidance of forearm supination with valgus loading may be advocated for those patients with a low level of symptoms. In cases of recurrent symptoms, operative management may be undertaken via direct repair or reattachment of the ligament or to reconstruct the lateral ligament complex with a tendon graft reconstruction. The results following surgical reconstruction, though limited, are promising (Nestor et al 1992, Lee & Teo 2003) with resolution of symptoms, full range of motion and a return to activity. Operative care may also be advocated for correction of cubitus varus with those patients who demonstrate positive physical exam signs for PLRI (O’Driscoll et al 2001a).

### Medial elbow instability

#### Anatomy review for medial elbow instability

There are three ligaments of the medial collateral ligament (MCL) complex, namely the anterior oblique/bundle, the posterior oblique/band, and the transverse ligament/band. The origin of the MCL is slightly posterior to the elbow joint, demonstrating greater tension with increasing flexion. The anterior bundle of the MCL is the strongest of the three and attaches from the medial epicondyle to the medial coronoid process. Histologically, the anterior bundle may be further divided into anterior and posterior bands (Safran & Baillargeon 2005). The anterior band is primarily taut from full extension to 60° of flexion. The posterior band of the anterior bundle is

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**Table 24.1** Orthopaedic examination techniques for lateral elbow instability—cont’d

<table>
<thead>
<tr>
<th>Name of test</th>
<th>Physical exam technique</th>
<th>Outcome to indicate a positive test for pathology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterolateral instability test</td>
<td>The examiner flexes the elbow to 40°, with the forearm in external rotation: an antero-posterior force is applied to the ulna and radius (O’Driscoll et al 2001b)</td>
<td>Subluxation of the forearm away from the humerus.</td>
</tr>
<tr>
<td>Push up sign (from floor)</td>
<td>Patient pushes up from the floor with shoulders in abduction, forearms supinated.</td>
<td>Apprehension and voluntary/involuntary guarding as involved elbow moves towards terminal extension</td>
</tr>
<tr>
<td>Tabletop relocation test</td>
<td>3-step test: 1. Patient performs a press up from a table top with forearm in supination. 2. With onset of symptoms (approximately 40° of flexion) examiner applies a force through their thumb at the patient’s radial head 3. Then the examiner removes the force at the radial head.</td>
<td>First outcome: pain and apprehension. Second outcome: pain and apprehension are reduced. Third outcome: pain/apprehension returns.</td>
</tr>
</tbody>
</table>
taut from 60° to 120° of flexion (Cohen & Bruno 2001, Safran 2004, Safran & Baillargeon 2005). The posterior oblique portion of the MCL complex is a thickening of the capsule that has the greatest restraint at 90° of elbow flexion. It arises from the medial epicondyle and inserts onto the medial side of the semilunar notch. The third portion of the MCL is the transverse ligament arising from the medial olecranon and the inferior medial coronoid process. It has limited impact, is variably present, and is often indistinguishable from the capsule (Cohen & Bruno 2001, Safran & Baillargeon 2005).

Additional stabilizers of the elbow include the radio-capitellar joint and the regional muscles. The radio-capitellar joint contributes up to 30% of the stability against valgus stress. The regional muscles of the pronator and the flexors may also have a role; however; the significance of their contribution is not yet completely understood (Cohen & Bruno 2001, Safran 2004).

Incidence/prevalence of medial elbow instability

Injury to the MCL is more common in the overhead athlete population than the non-thrower population. In the throwing athlete, consequences of such instability may include the inability to compete at the desired level. In the general population, it rarely affects activities of daily living (Grace & Field 2008) unless there is a specified job task within the work environment. Bennett et al (1992) provide one example with industrial workers who demonstrated symptoms of chronic medial ligament instability during specific work tasks eventually requiring surgical intervention for return to work.

Pathology/patho-anatomy of medial elbow instability

There are two mechanisms for MCL laxity: acute or spontaneous and chronic attenuation. The symptoms that the patient will report may differ between the two incidences. A ‘pop’ may be heard in the more acute cases whereas there may be a report of vague elbow discomfort that becomes more prevalent over a length of time in a mechanism which involves chronic attenuation.

The mechanics of throwing have been studied to determine the contribution to medial collateral laxity. Of note, the MCL (primarily the anterior bundle) provides up to 54% of the varus torque to resist the valgus strain in the elbow during the late cocking and early deceleration phases of throwing (Fleisig et al 1995). The ultimate failure load of the MCL is calculated to be less (34 Nm) than the loads that it is exposed to during the majority of overhead sports (52–120 Nm) (Fleisig et al 1995). Therefore, it is hypothesized that there is a significant influence from the proximal segments and core of the upper extremity to generate secondary constraints for control of these forces (Kibler & Sciascia 2004). It is suggested that an imbalance of the contribution from the local structures and/or inadequate contribution from the proximal segments and core would create an environment of excessive strain which would result in attenuation over time.

Typically with a chronic condition, the MCL laxity may represent only one aspect of a constellation of injuries that contribute to the medial elbow pain. For example, the ligament injury may be a part of valgus extension overload syndrome which involves the compression of the olecranon of the ulna against the humerus with a valgus stress. Associated injuries may include: capitellar wear, posteromedial osteophytes, ulnar neuritis, and degenerative or traumatic arthritis of the elbow. Furthermore, due to the dynamic nature of the population this pathology is often associated with, it is important to consider the influence of the kinetic chain. In two different reports, findings indicated that professional baseball players presenting with both medial elbow symptoms of insufficiency and significant gleno-humeral internal rotation deficits, demonstrate a kinetic chain relationship where impairments outside of the local region may have a causal relationship to the symptoms reported at the elbow (Kibler & Sciascia 2004, Dines et al 2009).

Diagnosis of medial elbow instability

Patient history should not only include location, duration of symptoms and the mechanism of injury but also the details of a throwing or overhead movement history if the patient is an athlete (Safran 2004). The patient presentation may be complicated with the complaints from the secondary structures involved in the overload mechanism including muscular strain, inflammation, or tendinosis that may be associated with the underlying instability.

Physical exam includes palpation, observation for a cubitus varus deformity, range of motion and special orthopedic testing that may be passive or active (Table 24.2). With palpation, the clinician may find tenderness approximately 2 cm distal from the medial epicondyle at the ulnar insertion of MCL. This tenderness has been reported in as many as 80% of those patients undergoing MCL reconstruction. Range of motion limitations may often include a flexion contracture (Thompson et al 2001).

For specific physical exam measures such as the valgus stress test and the milking manoeuvre statistical evidence is limited. Similar to the special testing of the lateral ligaments of the elbow, consideration must be paid to the supportive roles of the secondary soft tissue constraints. For example, during the valgus stress test, it has been stated that the position of supination for the forearm should provide a greater bias of the MCL over the contribution from the LCL (Smith et al 2001). However, in a cadaveric study by Safran et al (2005) where both the anterior and posterior bands of the anterior bundle of the MCL were sectioned and tested at various angles of
flexion and forearm position, the neutral position of the forearm in relationship to the horizontal, regardless of the degree of elbow flexion, assessed the integrity of the MCL more clearly than any other position. It should be noted, that this alteration in the procedure of the valgus stress test has not been tested in humans, therefore the information must be viewed cautiously.

For detection of medial ligament instability such as commonly seen with partial tearing or attenuation in the throwing athlete, the moving valgus stress test as described by O’Driscoll et al (2005) is the most widely used with supportive statistical evidence of sensitivity of 1.0 and specificity of 0.75. Imaging techniques such as static imaging, stress radiographs, MRI, CT scan and arthroscopic valgus stress testing have all been utilized with varying degrees of success (O’Driscoll et al 2005).

Prognosis and treatment planning for patients with medial elbow instability

Treatment of non-throwers and the general population is via a non-operative rehabilitation programme with reported successful return to the activities of daily living without symptoms (Grace & Field 2008). For that subset of patients wishing to return to high demand throwing, non-operative therapy is attempted initially and with a failure to return, operative management is considered.

In a single study by Rettig et al (2001) throwers with chronic medial instability were treated non-operatively. They achieved a 42% success rate in returning the athlete to sport within an average of 24.5 weeks. The rehabilitation was divided into two phases. The first phase involved a rest from throwing for up to three months, resolution of inflammation including brace wear and achievement of full range of motion. The second phase included a progressive strengthening programme and stepwise progression towards a return to throwing.

Information gained from cadaveric studies can provide cues for rehabilitation. Armstrong et al (2000) studied the MCL in cadaveric elbow and concluded that active mobilization of the elbow in the vertical position with either a fully supinated or pronated forearm position is safe for decreased stress at the ligament. With tension in the medial structures, one might construct a rehabilitation programme which incorporates limited humeral external rotation in combination with neutral forearm positioning and avoidance of valgus stresses especially during 70–120 degrees of elbow flexion. In a cadaveric study by Bernas et al (2009) the immediate post rehabilitative phase was concluded to be an appropriate time to introduce isometric flexion and extension below 90° of flexion and to limit motion from full extension to 50° of flexion to protect the MCL.

ARTHRITIC CONDITIONS

Anatomy review for arthritic conditions of the elbow

The elbow is comprised of three articulations: the ulna articulating with the humerus, the ulna articulating with the radius and the radius articulating with the humerus. There are two degrees of freedom in the elbow joint: flexion/extension and pronation/supination. The functional arc of motion of the elbow is 30–130°. A total range of
less than 100° degrees in the sagittal plane or the transverse plane will generate significant functional limitations (Morrey et al 1981).

**Incidence/prevalence of arthritic conditions of the elbow**

Arthritis of the elbow is relatively uncommon. It typically falls into three categories: rheumatoid arthritis (RA), post traumatic arthritis or primary degenerative osteoarthritis (OA). In the patient population with RA, it has been found that 25–66% of the patients may have the presence of disease in one or both elbows (Porter et al 1974, Lehtinen et al 2001). Primary degenerative arthritis of the elbow has been reported to affect less than 2% of the population (Antuna et al 2002). Though the theory remains somewhat controversial, it is generally accepted that primary OA of the elbow affects males with a history of 'heavy use of the upper extremity' such as industrial labour, weight lifting etc. (Gramstad & Galatz 2006, Kokkalis et al 2009). These patients are typically not less than 40 years of age (Gramstad & Galatz 2006).

**Pathology/patho-anatomy of arthritic conditions of the elbow**

Rheumatoid arthritis is an inflammatory disease process that affects multiple joints. It is characterized by symmetric joint narrowing, disuse osteopenia and peri-articular erosions which will be seen on radiographic imaging (Kokkalis et al 2009). The course and natural history of the osteoarthritis is not well understood, however; it is typically characterized by destruction of the articular cartilage (Gramstad & Galatz 2006). Primary osteoarthritis of the elbow demonstrates unique features such as sparing of the articular surfaces with preservation of the joint spaces and hypertrophic formation of osteophytes and capsular constriction (Cheung et al 2008). Osteoarthritis begins on the lateral aspect of the joint at the radio-capitellar joint (Goodfellow & Bullough 1967). In the younger population with a presentation of elbow stiffness, post traumatic arthritis should be suspected. Associated disorders to this pathology include: trauma, osteochondritis dissecans, synovial chondromatosis and valgus extension overload syndrome (Gramstad & Galatz 2006).

**Diagnosis of arthritic conditions of the elbow**

Generally, the patient reports pain, stiffness and potential weakness. Functionally, they often have symptoms with attempts at carrying a weighted object next to the body when the elbow is extended. Dependent on the underlying cause of the arthritis, the patient reports may vary. For example, a patient with elbow pain secondary to RA may complain of pain throughout the range of motion (Soojian & Kwon 2007). A patient with osteoarthritis may have concerns of ‘pinching’ or ‘sharp pain’ with terminal flexion or extension during the earlier stages of the disease (Cheung et al 2008), whereas, patients with a diagnosis of post-traumatic arthritis may be younger and healthier than those with RA or OA with less involvement of other body regions. These patients may also possess an expectation of higher demand of the elbow (Amirfeyz & Blewitt 2009). In Table 24.3, specific features of each of the most common pathologies associated with elbow arthritis are highlighted.

A detailed interview of the patient to note the onset of symptoms, course of associated disease process or prior surgical/traumatic history is necessary. Prior treatment for either the arthritic disease or specifically to the elbow should be inquired of including pharmacologic therapies.

<table>
<thead>
<tr>
<th>Underlying disease</th>
<th>Patient report</th>
<th>Comments</th>
</tr>
</thead>
</table>
| Rheumatoid arthritis | Pain throughout the range of motion | Loss of rotation
| | | Excessive motion in the coronal plane (Soojian & Kwon 2007)
| | | Possible underlying instability |
| Post-traumatic arthritis | Stiffness and pain with inadequate end ROM | History of trauma, surgery to joint
| | | Possible underlying instability |
| Primary degenerative OA | Initially, pain only at the terminal ROM In later stages, pain throughout the ROM Catching/locking may be reported | Need to monitor progression of disease as this impacts treatment |
Radiographs are the standard to determine the phase of the disease process and the potential plan of care. Of special note, one should recognize potential differential diagnoses which may produce similar patient concerns including septic arthritis, crystalline arthropathy, haemophilia and ochronosis (Soojian & Kwon 2007).

**Prognosis and treatment planning for patients with arthritic conditions of the elbow**

The underlying aetiology, functional limitations including the current range of motion of the elbow and the age of the patient significantly influence treatment course. The current standard is non-operative treatment which may include pharmacologic management, corticosteroid injections, dynamic splinting, and physical therapy (Gramstad & Galatz 2006, Kokkalis et al 2009). With the advent of improved and more aggressive treatment of RA, one report stated that early management has the potential for complete resolution of symptoms in 10% of patients treated (Brasington 2009). For patients with primary OA at the elbow, activity modification is typically suggested with varying results.

With failure of such non-operative measures to resolve the patient's functional limitations or symptoms, there is a wide variety of surgical options including arthroscopy and arthroplasty. The best results for management of OA and post-traumatic OA within the younger patient population has been reported via arthroscopy for a capsular release and clearing of osteophytes (Gramstad & Galatz 2006). The total elbow arthroplasty is typically reserved for the population that is greater than 60 years of age, has lower physical demands and who are more likely to comply with the post operative rehabilitative and long term physical restrictions (Moro & King 2000).

**CONCLUSION**

In recent years, there has been a significant gain in understanding of the anatomy and pathologies of the elbow which cause instability and stiffness. With the discovery of this information more research needs to be completed to develop rehabilitation guidelines which produce successful outcomes.

**REFERENCES**
