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Review

Olecranon fractures

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ABSTRACT

Several options exist for the management olecranon fractures. These include tension band, plate and intramedullary fixation techniques as well as fragment excision with triceps advancement and non-operative management. No one technique is suitable for the management of all olecranon fractures. In deciding how to treat this common trauma presentation, the surgeon needs a good understanding of the anatomy, different fracture morphologies, surgical options and potential complications. With appropriate management and early mobilisation good functional results can be expected in the majority of patients.

Contents

Introduction

Olecranon fractures comprise approximately 10% of all fractures around the elbow[36] and a diverse array of treatment options have continued to evolve for the management of this common trauma presentation. Olecranon fractures vary in their complexity from relatively straightforward transverse fractures to comminuted and unstable configurations. The spectrum of management options available is a consequence of the fact that no particular mode of treatment can be universally applied to the diverse array of fracture patterns encountered. To appropriately manage these fractures, the surgeon needs to have a good

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understanding of the anatomy, available treatment options and potential complications.

Anatomy

The elbow is a complex hinge joint capable of a flexion arc of 0–150°. The joint is stabilised by a number of factors including the anterior coronoid process and posterior olecranon process which resist the translational forces of the humerus on the ulna. Resistance to valgus stress is provided by the anterior band of the ulnar collateral ligament and the radial head. Varus stress is countered by the lateral collateral ligament complex.

The articular surfaces are lined with hyaline cartilage. The trochlea notch of the ulna, which articulates with the trochlea of the humerus, has a characteristic transverse "bare area" at the junction between the anterior third and the posterior two thirds. This area varies in size between individuals, but in one cadaveric study of 39 elbows was shown to have a mean width of 5.3 mm[41]. Knowledge of this area is important when reducing olecranon fractures as it can be tempting, but incorrect, to eliminate any articular surface not covered by cartilage.

The triceps brachii inserts into the posterior third of the olecranon and the proximal ulna, blending with the aponeurosis overlying anconeus and the common extensor mechanism. The olecranon process periosteum and triceps tendon are closely associated. The brachialis inserts into the coronoid process of the ulna and along with the triceps helps to produce compressive forces across the elbow joint during contraction.

Mechanism of injury

Olecranon fractures can occur as a result of either direct or indirect trauma. The subcutaneous location of the olecranon makes it susceptible to injury by direct trauma. Laboratory studies have shown that the degree of elbow flexion at the time of direct trauma affects the subsequent likely fracture pattern. Radial head and coronoid fractures occur at flexion of less than 80°, olecranon fractures at 90° of flexion and distal humeral fractures at greater than 110°[1]. Direct trauma often produces comminuted fractures as the olecranon is impacted into the distal humerus. Indirect fractures of the olecranon occur as a result of forceful contraction of the triceps often during a fall onto an outstretched arm, this tends to produce transverse or short oblique fractures. Olecranon fractures may be displaced or undisplaced. Displacement occurs as a result of disruption of the periosteum and triceps aponeurosis combined with contraction of the triceps. Olecranon fractures occur less frequently in children than adults as the paediatric olecranon is short, thick and relatively stronger than the distal humerus, consequently children sustain supracondylar humeral injuries more frequently than olecranon fractures.

Classification

Multiple classification systems have been devised for olecranon fractures, although none have gained widespread acceptance. Colton et al.[8] were the first, developing a system based on the displacement and character of the fracture. Type I fractures are undisplaced and stable. Type II fractures are unstable and subdivided according to fracture pattern: type IIA avulsion fractures, type IIB transverse or oblique fractures, type IIC isolated comminuted fractures and type IID are fracture dislocations. The AO classification of proximal radius and ulna fractures are divided into three broad groups. Type A are extra-articular fractures of either radius or ulna, type B are intra-articular fractures of either bone, with type B1 being specifically an intra-articular fracture of the olecranon alone, type C fractures are intra-articular fractures of both radius and ulna[24]. The Schatzker classification (Fig. 1) is based on the fracture pattern and a consideration of the type of internal fixation required[5]. The Mayo clinic classification, as displayed in Fig. 2, is one of the most frequently used and describes fractures on the basis of stability, displacement and comminution. Type I fractures are undisplaced and stable, type II are displaced and unstable fractures but with intact collateral ligaments preventing dislocation and in type III fractures the elbow joint is unstable. Type II and III fractures are further subdivided into A (non-comminuted) and B (comminuted)[28]. Elbow stability is associated with a poorer prognosis following olecranon fracture. The Schatzker and Mayo classifications can be useful in predicting prognosis, with Schatzker types C (oblique) and D (comminuted) and Mayo type III fractures associated with less favorable outcomes[36].

Patient assessment

The assessment of patients with a suspected olecranon fracture should begin with a careful examination of the skin for evidence of an open fracture. The olecranon is subcutaneous and it is often possible to carefully palpate the fracture. A full neurovascular assessment of the upper limb should be documented. Antero-posterior and lateral radiographs should be obtained of the elbow. Although olecranon fractures are usually isolated injuries, careful assessment of the radiographs should be made to exclude coronoid fractures, radial head fractures and Monteggia fracture dislocations which have a significant impact on elbow stability.

Management

Olecranon fractures are all intra-articular injuries. The aims of treatment, as defined by the AO group, are to restore the articular surface, achieve absolute stability of the fracture, and commence early active motion[29]. However, the method of treatment must also consider the configuration of the fracture, the patient's co-

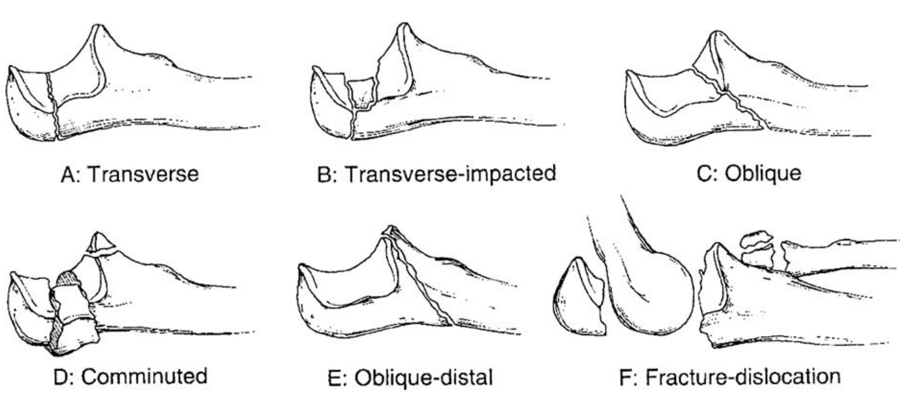

Fig. 1. Schatzker classification of olecranon fractures (adapted with permission from Browner et al.[5]).

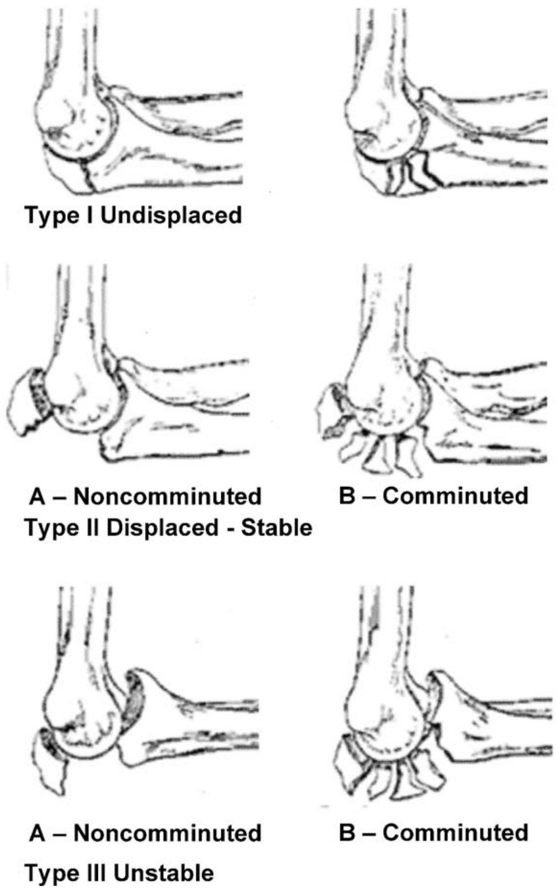

Fig. 2. The Mayo classification of olecranon fractures. The classification is based on consideration of the stability, displacement and comminution of the fracture. (Reproduced, with permission, from Morrey and Adams[26], The Copyright of The Mayo Clinic Foundation Section of Publication.)

morbidities and functional demands. Internal fixation or excision of the fragment with triceps advancement is necessary in most cases, but non-operative management can be employed when appropriate.

Non-operative management

Patients with undisplaced olecranon fractures can be treated non-operatively with immobilisation at 45–90° of flexion for approximately 3 weeks before commencing limited flexion (90°) exercises until radiographic evidence of union is achieved[17]. Some controversy exists over the degree of displacement that is deemed acceptable; 2 mm is often quoted as the maximum displacement allowable for conservative management[38]. However, elderly patients can have good functional outcomes despite significant displacement. In a series of 13 patients treated non-operatively of mean age 81.8 years with >5 mm displacement, Veras Del Monte et al.[39] found only 1 patient had a poor functional outcome.

Operative management

Four principle methods of operative management of olecranon fractures are in use: tension band fixation, intramedullary fixation, plate fixation and excision of the proximal fragment with triceps advancement.

Tension band fixation

Tension band wire fixation is by far the commonest technique of internal fixation used for the treatment of non-comminuted olecranon fractures. The tension band technique involves converting the distracting (tension) force of the triceps into a dynamic compressive force at the articular surface. We perform a modified version of tension band wiring technique as taught on AO courses. We use two 1.6 or 2.0 mm Kirschner wires (K-wires), which are inserted into the olecranon and passed as close as possible to the articular surface without penetrating the articular cartilage or the anterior cortex of the ulna. The wires are backed out approximately 1 cm from their final planned position and cut approximately 2 cm from the bone surface. The wires are cut obliquely so as to make a point and the ends of the wires are then bent through two 90° bends. An intravenous cannula is passed from the medial side (so as to avoid ulnar nerve injury) anterior (i.e. deep) to the triceps tendon, and used as a guide to pass an 18 gauge wire which rests against the proximal ulna. A 2.0 mm drill hole is made near to the posterior cortex of the ulna approximately 2 cm distal to the fracture site. A second wire is passed through the ulnar drill hole and the ends are crossed over the ulna so as to form a figure of eight with the first wire. The wires are then twisted together on either side of the ulna, tightening the figure of eight construct. Finally, two small incisions are made in the triceps in line with its fibres at the insertion of each of the K-wires and the wires are impacted into the distal ulna (Figs. 3 and 4). The joint should be manipulated

Fig. 3. Antero-posterior radiograph showing tension band wiring for olecranon fracture.

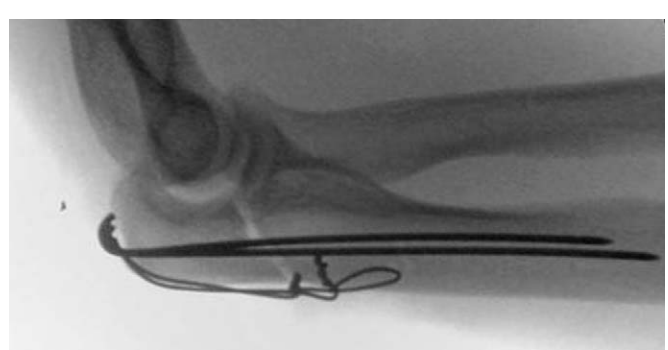

Fig. 4. Lateral radiograph showing tension band wiring for olecranon fracture.

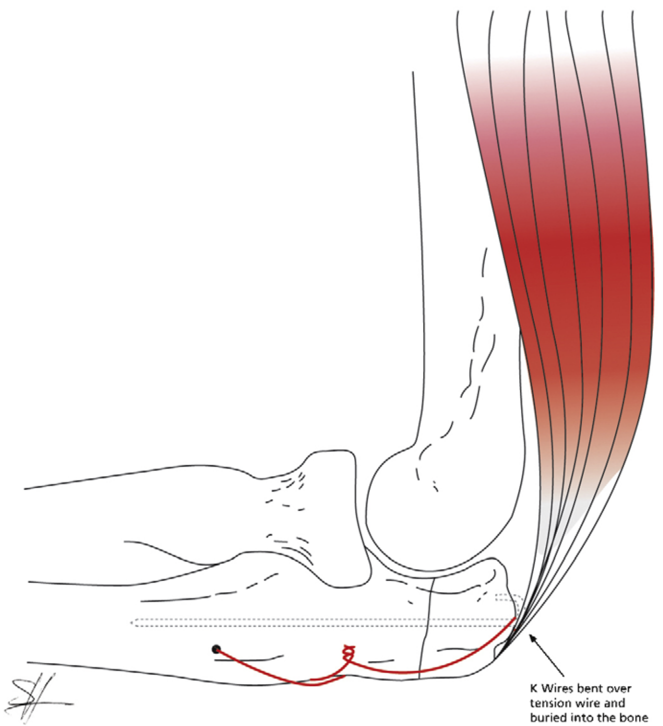

Fig. 5. Lateral view of tension band wiring construct.

prior to closing ensuring there is no impingement of flexion/extension or supination/pronation (Figs. 5 and 6).

The tension band wire technique has been studied more than any other internal fixation technique for olecranon fractures and a great deal of variation exists between individual surgeons practice. Tension band wiring can be performed without the use of K-wires, but is technically more difficult and in a study by Karlsson et al.[21] was actually associated with a higher re-operation rate for removal of metalwork. The positioning of the K-wires, specifically whether to penetrate the anterior ulna cortex, has caused controversy. Advocates of cortical penetration believe that it reduces the risk of K-wire migration and cadaveric studies have shown that K-wires that penetrate the anterior cortex require approximately double the force of intramedullary K-wires to "pull out" [30,35]. However, others believe that K-wire "pull out" is related to the action of triceps during extension on non-impacted wires rather than whether the K-wires penetrate the anterior cortex[45]. Furthermore, anterior cortical perforation is associated with a risk of anterior interosseous nerve injury and impaired forearm rotation[6,33,34]. There is also a potential risk of vascular injury, with the ulnar artery most at risk of inadvertent penetration. An MRI study by Prayson et al.[34] showed that the median nerve and ulnar artery were the most susceptible structures to K-wire penetration, although damage to either structure would require passage of the wire over 10 mm beyond the anterior cortex.

The choice of material used to form the figure of eight has been investigated by a number of groups. Prayson et al.[35] showed in a cadaveric study that the use of braided cable instead of monofilament wire produced a more stable construct, particularly when this was combined with intramedullary screws replacing the K-wires. Polyester suture has been used successfully by some groups as an alternative to mono-filament wire[7,23], however the number of loops of suture used may need to be greater than for wire to maintain the same stability[15]. The use of two twisted knots, one radial and one ulna was shown by Fyfe et al.[10] to be a more stable construct than the single knot tension band wire technique originally described by Weber and Vasey[42].

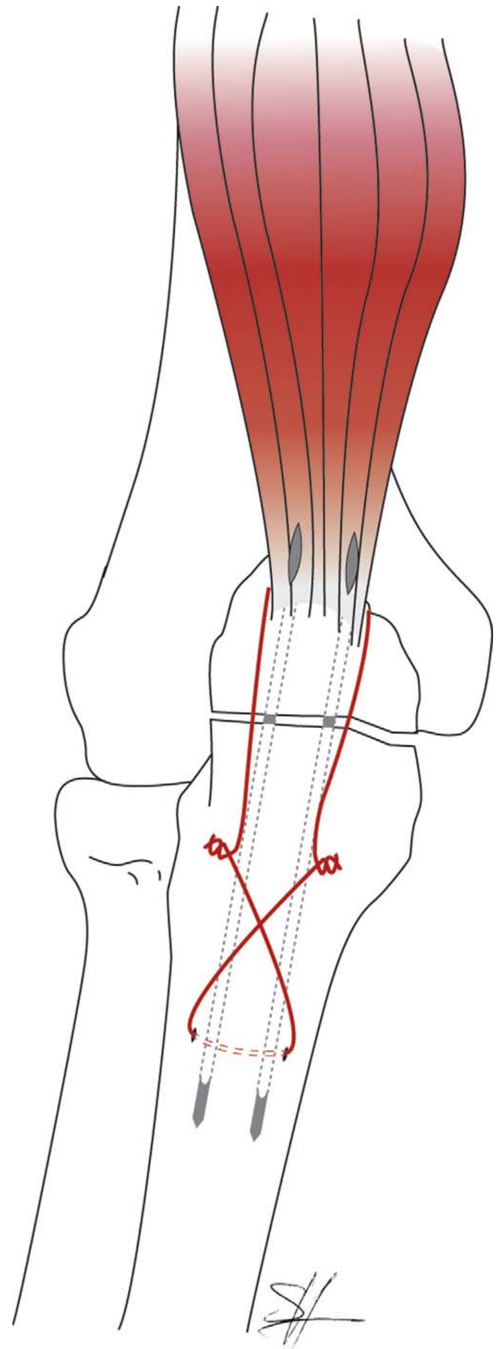

Fig. 6. Antero-posterior view of tension band wiring construct.

Intramedullary fixation

Intramedullary screws and nailing systems have been used by some authors for the treatment of olecranon fractures and osteotomies. A single intramedullary cancellous screw can be used with or without tension band wiring to treat simple transverse or oblique olecranon fractures. Although one study showed a greater loss of fixation when using an intramedullary screw alone compared to tension band wiring[16], other authors have reported good results using this technique with or without supplementary tension band wiring[20,40].

Ex vivo studies have shown intramedullary nailing systems offer greater fracture stability than tension band wiring[27,31]. The technique requires less exposure than tension band fixation and can be used effectively in simple and comminuted fractures of the olecranon. In a series described by Gehr and Friedl[12], fixation of 73 patients with a mixture of simple and comminuted olecranon fractures was undertaken using a locking compression nail. They reported good or excellent functional results in 68 of the cases.

Plating

Plate fixation has been used principally for the management of comminuted olecranon fractures in which tension band wire fixation is not appropriate. Other indications include oblique fractures distal to the midpoint of the trochlear notch, co-existing coronoid fractures and olecranon fractures associated with Monteggia fracture dislocations of the elbow[14]. One-third tubular, 3.5 mm contoured limited contact dynamic compression (LC–DC), 3.5 mm reconstruction, hook plates and pre-contoured locking plates are frequently used[24]. Some surgeons choose to use hook plates with prongs that impact into the displaced olecranon fragment. These can be adapted third tubular plates or specially designed devices such as the classic Zuelzer Hook Plate[43]. Anatomically contoured locking plates are one of the newest developments in olecranon plate technology and are being marketed as offering superior fixation as a result of the fixed angle construct. Whilst good results have been shown with the use of these plates[3], there is currently insufficient evidence to suggest they are superior to other forms of plate fixation. In severely comminuted fractures, reconstruction with a one-third tubular plate may not offer sufficient strength and may lead to hardware failure[14].

Plates are most commonly applied to the dorsal surface of the ulna. This is the tension side of the olecranon which makes the construct most biomechanically sound, furthermore screws can be passed into the coronoid or inserted along the medullary canal for extra stability. In severely comminuted fractures the use of plate fixation offers the option of bone grafting to support depressed articular fragments (Figs. 7 and 8).

The subcutaneous nature of the plate has led to concerns about the prominence of the hardware. However the incidence of symptomatic hardware protrusion is lower in plate fixation than tension band wiring[18,44] with 0–20% of cases requiring plate removal[4,37]. Some advocate plating the medial and/or lateral ulna to improve soft tissue cover, but this is biomechanically inferior to plating of the dorsal ulna, which has been shown to be 48% stronger than plating the medial and/or lateral surface[13].

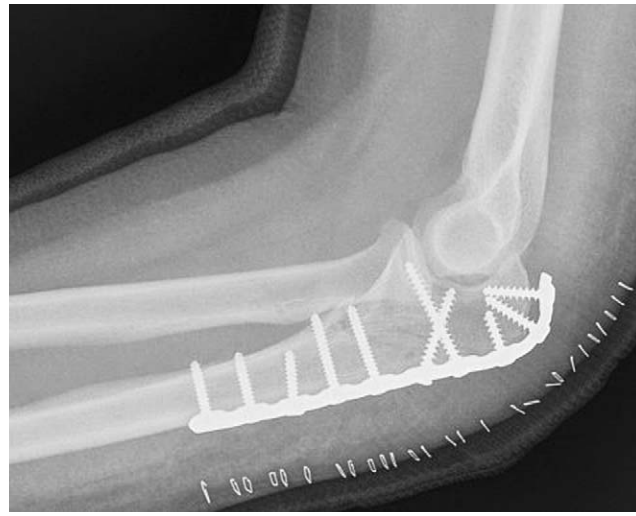

Fig. 7. Lateral radiograph of plating and screws for olecranon fracture.

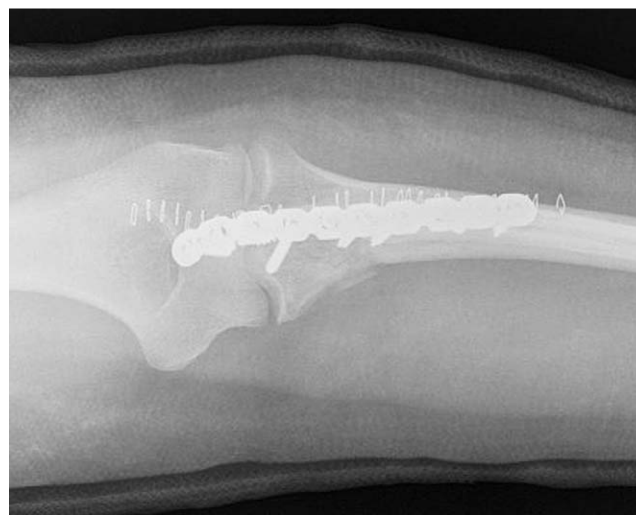

Fig. 8. Antero-posterior radiograph of plating and screws for olecranon fracture.

Proximal fragment excision and triceps advancement

In elderly patients with osteoporotic bone, extensive comminution or a fragment too small for internal fixation, excision of the fracture fragment with triceps advancement can be a useful option. The technique has significant advantages as it avoids the possibility of non-union and traumatic arthritis due to irregularity in the articular surface. Fragment excision can only be performed if the coronoid, medial collateral ligament, interosseous membrane and distal radio-ulnar joint are intact to prevent instability[14].

McKeever and Buck[25] who first described this technique in 1947 suggested that up to 80% of the trochlear notch can be excised without appreciably compromising elbow stability. Inhofe and Howard[19] showed good or excellent outcomes in 11 of 12 cases treated with excision of up to 70% of the trochlear notch. However Gartsman et al.[11] reported a case of instability after resection of 75% of the trochlear notch and an in vitro study by An et al.[2] showed a linear reduction in elbow stability with greater than 50% resections. A criticism of the technique is that a reduction in triceps strength occurs. Normally the triceps tendon is sutured to the anterior edge of the ulna creating a smooth sling for articulation with the distal humerus. An alternative position for reattachment of the triceps tendon has been suggested by DiDonna et al.[9], in their biomechanical study the triceps was reattached in a more posterior position which was found to increase triceps strength relative to the more anterior attachment.

In general, fragment excision and triceps advancement is considered in cases where open reduction and internal fixation is unlikely to be successful. Internal fixation offers the advantage of early mobilisation and bone to bone healing as opposed to immobilisation and suture fixation. The technique can be used as a salvage procedure at a later stage if internal fixation fails.

Rehabilitation

The exact post-operative regimen will be determined by the stability of fixation, wound healing and patient compliance. However, in our experience patients should be splinted in 45–90° of flexion to help manage post-operative pain. The splint should be discontinued after 5–7 days, passive and gentle active movements are commenced at this point. Active movements against resistance should be avoided until there is evidence of callous formation at approximately 6–8 weeks. In the case of fragment excision and triceps advancement, resistance exercises should be delayed until approximately 12 weeks.

Outcomes

The functional outcome following olecranon fracture fixation is generally good or excellent whatever method of fixation is used. A review of 73 cases by Karlsson et al.[22] comprised olecranon fractures treated principally by internal fixation (84%) showed that 96% of patients had a good or excellent outcome at 15–25 years follow up. In this study, degenerative change was found to be more likely following olecranon fracture, with changes noted in 50% of the formerly fractured elbows compared to 11% in the patients' previously uninjured elbow. Rommens et al.[36] clinically and radiologically reviewed 58 cases of olecranon fracture at a mean follow up of 36 months, they concluded that instability of the original fracture, the fracture morphology (Schatzker type C and D) and suboptimal fixation were associated with greater degrees of degenerative change.

The main complication following internal fixation of olecranon fractures is related to irritation caused by hardware. This is mostly related to tension band wiring although has been reported with the use of plate fixation. Loss of motion is commonly encountered after simple olecranon fracture fixation, but is rarely significant with patients typically losing 10–15° of extension. The loss of elbow motion is worse in cases associated with fractures of the radial head, capitellum, coronoid or Monteggia fracture-dislocations[14]. The risk of iatrogenic neurovascular injury is significant, particularly with anterior cortical penetration in tension band wiring and care should be taken to avoid over-penetration of the cortex.

Non-union has been reported in 1% of cases. Options for management include fragment excision, compression plate or lag screw fixation with or without bone graft and elbow arthroplasty. Papagelopoulos and Morrey[32] reported on the management of 24 patients with olecranon non-union. Using the above techniques they achieved excellent results in 12 patients, good in 4, fair in 6 and poor in 2.

Summary

Fractures of the olecranon are a common trauma presentation and multiple options exist for the management of these injuries. In general, internal fixation by tension band wiring is preferred in the majority of patients with simple fractures and good or excellent results can be expected as long as the surgeon ensures a good anatomical reduction of the articular surface. Intramedullary fixations with screws or nails are less commonly employed but are acceptable alternatives in experienced hands. Dorsal plate fixation can be used in simple fractures of the olecranon, but is particularly indicated in comminuted fractures and fracture-dislocations. Fragment excision and triceps advancement can offer good functional results in patients with failed internal fixation or who are unsuitable for internal fixation. Significant complication rates following internal fixation are low, but patients should be warned of the potential need for hardware removal.

Conflict of interest

The authors declare that there is no conflict of interest.

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