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Review article

Articular fractures of the distal humerus

T. Bégué*

Service de chirurgie orthopédique et traumatologique, université Paris-Sud, hôpital Antoine-Béclère, 157, rue de la Porte-de-Trivaux, 92140 Clamart, France

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ABSTRACT

Distal humeral fractures represent 2% of all adult elbow fractures. Injury mechanisms include high-energy trauma with skin involvement, and low energy trauma in osteoporotic bone. Treatment goals are anatomical restoration in young, high-demand patients and quick recovery of activities of daily living in the elderly. Complete fractures are relatively easy to diagnose, but partial intra-articular fractures are not. The clinical diagnosis must take into account potential complications such as open injuries and ulnar nerve trauma. Standard X-rays with additional distraction series in the operating room are sufficient in complete articular fracture cases. Partial intra-articular fractures will need CT scan and 3D reconstruction to fully evaluate the involved fragments. SOFCOT, AO/OTA and Dubberley classifications are the most useful for describing fractures and selecting treatment. Surgery is the optimal treatment and planning is based on fracture type. Complete fractures are treated using a posterior approach. Triceps management is a function of fracture lines and type of fixation planned. Constructs using two plates at 90° or 180° are the most stable, with additional frontal screw for intercondylar fractures. Elbow arthroplasty may be indicated in selected patients, having severely communited distal humerus fractures and osteoporotic bone. Open fractures make fixation and wound management more challenging and unfortunately have poorer outcomes. Other complications are elbow stiffness, non-union, malunion and heterotopic ossification.

1. Introduction

Articular fractures of the distal humerus in adults are difficult to treat because of their epiphyseal location. Although not a common fracture [1], approximately 3000 distal humerus fractures in adults and children are treated surgically every year in France [2]. An orthopaedic surgeon in France sees an average of five distal humerus fractures per year. Because these fractures are fairly rare, proposing a routine but specific management scheme is challenging.

The treatment process consists of determining the injury mechanism, defining the diagnostic modalities and developing a treatment algorithm to allow the patient to completely regain full mobility of this complex joint. Normal function is hard to restore if the joint is deformed by malunion and/or stiffened by heterotopic ossifications or capsular and ligament contractures.

2. Anatomy

In the frontal plane, the distal humerus has a triangular shape, is empty in the middle and is made up of a horizontal capitellum-trochlea segment inserted between the medial and lateral columns [3]. The interposed segment extends more distally than the columns, thereby resembling a cylinder pinched between the tips of the index finger and thumb [4]. The central area comprises a coronoid fossa and an olecranon fossa. This area is quite thin, which allows extensive range of flexion and extension, but also generates weak point contributing to complex fractures, especially in the elderly.

The medial column holds the medial epicondyle and medial portion of the humeral trochlea. When viewed from the side, this medial column appears continuous with the humeral shaft axis. Conversely, the lateral column is flexed relative to the humeral shaft, placing the capitellum ahead of the trochlea. The epiphyseal section of the distal humerus containing the trochlear and capitellum articular surfaces is in 4–8° valgus relative to the shaft, externally rotated by 3–8° relative to the metaphysis and flexed 40° relative to the shaft [5], resulting in the distal humerus being projected in front of the humeral shaft.

3. Fracture mechanism

Complete fractures result from impaction of the proximal ulna onto the articular part (trochlea, capitellum) of the distal humerus. The impact can occur with the elbow flexed or extended. If the elbow was flexed at impact, the articular fragments move forward; if the elbow was extended, they typically move backwards [3]. Some believe that contre-coup impaction towards the lower end of the humeral shaft results in separation of the medial and lateral

* Tel.: +33 01 45 37 47 34; fax: +33 01 45 37 49 50.
E-mail addresses: thierry.begue@abc.aphp.fr, tcbegue@free.fr

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columns. Because of the complexity of the injury mechanisms, comminuted fractures are quite common, especially in the elderly.

Partial sagittal fractures of the lateral or medial condyle are the result of indirect trauma in valgus or varus while in full or nearly full extension. These fractures are accompanied by capsular and ligament injuries on the opposite side of the joint. The elbow will be acutely unstable.

Isolated capitellum fractures are the result of compression of the articular surface by the radial head (as if the radial head gave the capitellum an uppercut) [6], either during the injury event with the elbow nearly in full extension or as a result of direct trauma to a highly flexed elbow. The position of the capitellum fragment on X-rays can help determine the position of the elbow during the injury [3].

4. Diagnosis

The clinical diagnosis is made when the patient presents a painfully swollen and deformed elbow. Because of the articular nature of the fracture, anatomical landmarks are disrupted. In complete bicondylar fractures, the two condyles can be moved independently of each other. In partial sagittal fractures, one of the condyles will be detached from the remainder of the humerus and moving freely. The forearm will be shorter because of proximal ulna migration and show either valgus or varus deformity. There is complete functional disability.

The clinical diagnosis of complete or partial sagittal fractures is not particularly difficult. However, partial frontal fractures of the capitellum or trochlea can go unrecognised. The functional loss is hard to detect, but will reveal itself as either a passive or active flexion or extension deficit. The elbow shape is normal. Anatomical landmarks are in their usual location. Hemarthrosis with filling of the posterolateral recess of the elbow is a sign of intra-articular injury [6]. The clinical appearance can be summarized as a painful swollen elbow after an injury event, which may explain the high number of delayed diagnoses for these fractures.

Skin lesions may occur posteriorly, where bone is located right under the skin. Open wounds add complexity when choosing the surgical approach [7]. Vascular complications are most common in supracondylar fractures. Fractures displaying signs of ischemia must be treated urgently. Nerve injury occurs in 25% of cases and affects either the median or ulnar nerves [8–11]. It is important to determine if the ulnar nerve is injured, as it will need to be transposed during the fixation process. Ruan [8] and Chen [10] believe that transposition is only necessary if the patient displays clinical signs before the surgery. If none are present, transposition is associated with worse results. There is no demonstrated link between the occurrence of postoperative ulnar neuropathy and the type of fixation hardware used [11].

5. Radiological evaluation

Standard AP and lateral X-rays of the elbow are sufficient for detecting complete fractures [12]. The AP view must allow the distal humerus to be viewed from the front, which is difficult to achieve in a position that is pain free for the patient. Because of the patient's pain and the displaced fragments, X-rays are often not sufficient to identify all the bone fragments, the degree of comminution, and allow for surgical planning. If the elbow is half-flexed, a CT scan is difficult to perform. We prefer taking X-rays with the arm in traction with the patient under general anaesthesia in the operating room; this allows us to align the fragments and get a good view of the distal humerus (Fig. 1).

CT scans are useful in partial or very distal fractures because the various fragments will be superimposed, which hinders precise analysis of the fracture on standard views. Three-dimensional reconstruction shows the shape and position of the bone fragments and is helpful in determining the appropriate surgical approach [14] (Fig. 2). A comparison of the diagnostic ability of 2D axial slices alone or in combination with 3D reconstruction was performed with partial distal fractures and complete fractures [14,15]. Inter-observer reproducibility was best with 3D reconstruction. In all fracture types, more bone fragments could be identified than when X-rays only were used. Others have found more limited benefits of 3D reconstruction, as it only improves intra-observer reproducibility [16]. Doornberg felt that CT scanning with 3D reconstruction was only truly useful during preoperative planning for distal humerus fracture treatment.

6. Classification systems

All of the proposed classification systems are based on determining the status of the columns and looking for sagittal or frontal fracture lines. The most used classification in France is the one put forward by Lecestre et al. [17] during the 1979 SOFCOT meeting. It effectively captures the various fracture types encountered. The AO/OTA classification system (Fig. 3) is a worldwide reference for published studies, but does not help the surgeon determine which treatment strategy is appropriate [18,19]. For distal humerus articular fractures, the Dubberley classification system [20] has the advantage of being able to differentiate between various fracture types involving the capitellum or trochlea and then suggesting a technique for treating each one (Fig. 4).

7. Treatment

7.1. Functional and conservative treatment

The elbow joint must be mobilized early on to avoid stiffening and heterotopic ossification. Because of axial loads, the joint cannot be moved without inducing secondary displacement. Immobilization is only feasible in cases of non-displaced fractures, or as a temporary treatment in the elderly before arthrolysis and arthroplasty [1,21]. Absolute non-surgical treatment can be justified in cases of hemiplegia sequelae involving the ipsilateral upper limb, advanced osteoporosis and fractures with extensive bone loss, but the functional result will always be unsatisfactory [1]. Functional treatment should only be considered in elderly patients when the fracture is located below the insertion of the collateral ligaments and muscles inserting on the epicondyles. The surgeon hopes for an ideal non-union, without risk of secondary displacement because the ligaments insert proximally to the fracture line [1,21].

7.2. Surgical treatment

Distal humerus fractures are primarily treated surgically. But partial and complete fractures require different treatment strategies. Techniques range from conservative surgical treatment using internal fixation in young patients to elbow joint replacement in older patients with comminuted fractures. Controversy exists as to the best was to position the plates on each column: 90° or 180° to each other. The availability of locking compression plates has changed how we plan internal fixation and can result in lower morbidity. The main goal of surgical treatment is to obtain fixation that is stable enough to allow immediate postoperative elbow mobilization and prevent it from stiffening. If the distal humerus fracture is immobilized in order to avoid fixation failure, stiffening is almost assured and arthrolysis will have to be performed later on.

7.2.1. Surgical approaches to the distal humerus

The choice of surgical approaches for internal fixation of distal humerus fracture is a difficult one to make, which justifies the need