11 Distal Humeral Osteotomy

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INTRODUCTION

Osteotomy of the distal humerus is a relatively uncommon and technically demanding procedure. Elbow anatomy and function are a complex interaction of the ulnohumeral, radiocapitellar, and proximal radioulnar joints. A clear understanding of the bony and soft tissue anatomy, as well as elbow kinematics, is necessary for a successful outcome following distal humeral osteotomy. This knowledge must include both normal elbow anatomy as well as the patient’s pathology.

Elbow functional range of motion is a 100-degree arc of motion between 30 degrees of extension and 130 degrees of flexion. The normal carrying angle of the elbow is between 7 and 14 degrees of valgus, with females having slightly higher valgus angles than males. The epicondylar axis is parallel to the articular surface in the coronal plane, and the distal humeral articular surface has a 30-degree anterior angulation in the sagittal plane. The epicondylar axis of the distal humerus is 3 degrees internally rotated in relation to the articular surface. Stability of the elbow joint is a complex interaction of bony, ligamentous, and muscular stabilizing forces. The primary stabilizers of the joint are the ulnohumeral articulation, the lateral ulnar collateral ligament, and the anterior band of the medial collateral ligament. Secondary stabilizers of the elbow include the radiocapitellar articulation as well as the tendon origins of the flexor and extensor muscles of the forearm.

Distal humeral deformities are often the result of malunited fractures in children and adults. In children, the deformity can often be well tolerated for several years. However, the abnormal alignment of the elbow results in growth disturbances, remodeling and wear of the remainder of the elbow joint that over time can lead to ligamentous insufficiency, and nerve dysfunction and degenerative changes in the elbow joint. The most common deformities are varus and extension of the distal humerus as a result of malunited supracondylar humerus fractures. Cubitus varus results in an abnormal vector of the triceps tendon that ultimately worsens the deformity and causes attenuation of the lateral ulnar collateral ligament leading to tardy posterolateral rotatory instability of the elbow.

INDICATIONS/CONTRAINDICATIONS

Patients with distal humeral malunions can present with a myriad of complaints. Typically these fall into three categories: the first is the patient who develops degenerative changes in the joint resulting in contractures and pain; while the second group develops instability and complains of progressive deformity and mechanical symptoms; the third group develops nerve-related symptoms as a result of the deformity. Symptomatic deformity of the distal humerus is the primary indication for an osteotomy, with the goal to restore alignment and joint biomechanics. In the face of instability, osteotomy to realign the joint forces is essential for success of the ligament reconstruction.

Clinical evaluation of the elbow alignment should be performed with the forearm supinated in and in full extension. The angle between the humeral shaft and ulnar shaft can be measured to determine the carrying angle of the humerus (Fig. 11-1). Care must be taken to avoid internal or external rotation of the shoulder as this can exacerbate or lessen the actual deformity, especially if a flexion contracture exists. Accurate assessment of range of motion, bony impingement, and stability of the elbow is essential. Signs of instability include catching or clicking with range of motion from flexion to extension as well as a positive posterolateral rotary drawer or pivot shift maneuver. Fluoroscopic evaluation allows for a dynamic examination of the elbow and aids in the assessment
of joint stability. Careful neurologic examination is important to assess for compression of the ulnar nerve in the cubital tunnel as a result of the deformity, instability, or a snapping medial triceps.

Computer tomography (CT) scan with three-dimensional (3D) reconstruction can be helpful in characterization of the deformity as most malunions have deformity in more than one plane. Newer computer software can also be used as part of the preoperative planning to determine the exact location and orientation of the osteotomy cuts to allow for appropriate realignment of the distal humerus. Advances in 3D printing methods now allow for the creation of plastic models that can be very helpful in understanding the deformity and planning the corrective osteotomy.

The primary indications for a distal humeral osteotomy are pain relief and to restoration of function associated with a malunion of the distal humerus. Typically, a symptomatic varus deformity greater than 15 degrees is an indication for distal humeral osteotomy. In the case of instability, the alignment of the distal humerus should be corrected at the time of ligament reconstruction.

Contraindications for distal humeral osteotomy include the presence of infection, patient non-compliance, or unrealistic expectations. Caution should be advised in patients who actively use tobacco or who have impaired healing ability due to underlying medical conditions or poor nutrition. The use of prophylactic osteotomy in the asymptomatic patient with significant deformity is debatable, and careful patient selection should be advised prior to proceeding with the procedure. The presence of degenerative changes in the elbow joint may be an indication for total elbow arthroplasty instead of corrective osteotomy. There is little information as to the degree of arthritic change that can be accepted in the osteotomy patient. Alternative treatment options for patients with minor deformity–associated degenerative changes and contracture include a debridement procedure with capsular release and recontouring ostectomy of the distal humerus to improve range of motion. In the face of instability associated with deformity in the elderly, low-demand patient-isolated ligament reconstruction may provide stability with less morbidity than an osteotomy. If the patient’s symptoms are isolated to the ulnar nerve, decompression or transposition of the nerve may be all that is needed. Careful preoperative evaluation is needed to assess which aspects of the patient’s pathology are actually symptomatic.

PREOPERATIVE PREPARATION

The development of a clear understanding of the patient’s deformities and anatomy is essential for a successful osteotomy. Full-length radiographs of bilateral upper extremities are useful for determining the degree of varus angulation of the humerus. The alignment or carrying angle of the arm can be assessed radiographically by determining the angle between the long axis of the humerus and the ulna (Fig. 11-2). The contralateral extremity alignment is helpful as a template for the desired degree of correction. The lateral radiograph can be examined for extension or flexion malunions by using drawing the anterior cortical line that should bisect the capitellum on the lateral radiograph.

A CT scan with 3D reconstruction is extremely valuable in understanding the degree and location of the deformity, especially with regard to rotational deformities of the distal humerus (Fig. 11-3A and B). We routinely obtain a CT scan prior to the surgery, and newer computer software allows for
templatizing of the proposed osteotomy, which is easier than the traditional paper cutouts that were used historically. In difficult cases with extreme deformities, a 3D model of the humerus can be obtained to allow for actual preoperative performance of the osteotomy on the model.

FIGURE 11-2
Bone length radiograph of the left upper extremity demonstrating the measurement of the varus deformity of 21 degrees.

FIGURE 11-3
Templating starts with drawing a line that is perpendicular to the long axis of the humeral shaft (A). A second line is drawn at an angle equal to the desired degree of correction and moved to 5 mm proximal to the olecranon fossa. The line perpendicular to the humeral shaft is moved distally until it contacts the second line. The third line is drawn from the point where the perpendicular line intersects the lateral humeral cortex to a point that is equal to the width of the humeral shaft along the distal line. This completes the template for the closing wedge osteotomy.

**SURGICAL TECHNIQUE**

The patient is positioned supine on the operating room table with the table tilted away from the surgical extremity to allow the arm to be positioned over the chest (Fig. 11-5). The arm can be brought out over the edge of the table for fluoroscopic imaging during the procedure. A sterile tourniquet is positioned on the upper arm. The arm should be examined under anesthesia using fluoroscopic imaging to assess for ligamentous instability. Close attention to the competence of the lateral ulnar collateral ligament is important and can be assessed using a pivot shift test or posterolateral drawer test.

The exposure of the distal humerus involves full exposure of the medial and lateral columns as well as the anterior and posterior cortices to allow for protection of the neurologic and vascular structures of the arm. This can be performed using a triceps on approach via a single posterior incision or a medial and lateral incision technique. Our preference is to use a two-incision technique that eliminates the need for raising large skin flaps and decreases the risk of wound-healing problems or seromas.

The medial incision is made along the medial column and starts 2 cm distal to the joint and extends 6 cm proximal to the joint. The ulnar nerve is identified proximally at the medial border...
of the triceps tendon. The nerve is mobilized through the cubital tunnel, including the fascia of the flexor carpi ulnaris. The nerve is mobilized anteriorly with care to coagulate the venous plexus along the posterior cortex of the distal humerus using bipolar cautery. The medial intermuscular septum is released from the medial epicondyle and excised to expose the medial column of the distal humerus. A Cobb elevator is then used to mobilize the triceps muscle from the posterior cortex of the distal humerus. The capsule of the elbow joint can be left intact. The brachialis muscle is released from the anterior cortex of the distal humerus with care to remember that the humerus has a triangular shape distally with an anterior angulation (Fig. 11-6).

The lateral exposure starts just distal to the lateral epicondyle and extends 6 cm proximally along the lateral column of the humerus. The interval between the triceps tendon and the brachioradialis is incised to expose the lateral column of the humerus. The triceps tendon is mobilized, and the posterolateral aspect of the distal humerus is exposed and connected to the medial incision. The brachioradialis and the brachialis muscles are mobilized from the anterior aspect of the distal humerus with care to stay subperiosteal to prevent injury to the radial nerve that is found between the brachialis and brachioradialis muscles. The radial nerve pierces the lateral intermuscular septum and crosses from the posterior compartment to the anterior compartment approximately 10 to 12 cm above the lateral epicondyle (Fig. 11-7).

Once the exposure is completed, the osteotomy cuts can be planned. The desired angle of correction is identified based on the preoperative templating, and care should be taken to account for flexion–extension or rotational malunions, which should be corrected at the time of the osteotomy. Using fluoroscopic imaging, a Steinmann pin is placed perpendicular to the long axis of the humerus. A goniometer is then used to place a second pin at the desired angle of correction 5 mm above the superior aspect of the olecranon fossa. Pin placement can be confirmed using fluoroscopic imaging to ensure the correct angle of correction (Fig. 11-8A–C).
FIGURE 11-7
Lateral column exposure showing elevation of brachioradialis and brachialis anteriorly and triceps posteriorly.

FIGURE 11-8
The use of pins as cutting guides helps facilitate making the correct degree of correction for the osteotomy. **A:** Intraoperative photograph demonstrating the use of fluoroscopy and goniometer to plan location of osteotomy cuts. **B:** Fluoroscopic image showing pin placement perpendicular to the humeral shaft axis and desired angle of correction. **C:** Intraoperative photograph demonstrating pin placement to be used as cutting guide for osteotomy.
The first cut is made along the distal pin that was placed at the desired angle of correction. The cut is made from medial to lateral just distal to the pin. Care is made to retract the ulnar nerve anteriorly and to protect the anterior and posterior soft tissues. The cut is made to a depth equal to the width of the distal humerus, which can be measured prior to making the cut and marked on the saw blade (Fig. 11-9A and B). The second cut is made parallel to the first pin, which was placed perpendicular to the axis of the humerus. The saw blade can be angled anteriorly or posteriorly to correct for extension or flexion malunions. The second cut is made completely through the entire distal humerus. The distal segment can then be translated laterally and a vertical cut is made, completing the triangular wedge of bone leaving a spike of distal humeral bone. The cut surfaces can then be reduced, and the lateral spike of bone on the distal fragment overlaps the lateral cortex of the proximal fragment. A Steinmann pin can be placed through the spike for provisional fixation of the osteotomy laterally and a second pin placed from the posterior aspect of the medial epicondyle into the lateral aspect of the proximal humeral shaft. The arm can then be examined clinically and fluoroscopically to confirm that the alignment is in 5 to 10 degrees of valgus. Definitive fixation of the osteotomy is then performed with medial and lateral plates. The distal fixation is performed first followed by proximal fixation with compression of the osteotomy site. The elbow is then examined to confirm full range of motion without impingement or blockage by the hardware. Fluoroscopic imaging is performed to confirm reduction of the osteotomy site and hardware placement without penetration into the articular surfaces (Fig. 11-10A and B).

The ulnar nerve is then examined, and if the nerve can be placed back to the anatomic position without impingement or instability with range of motion, it is left in the cubital tunnel. In the face of nerve impingement or subluxation of the nerve, an anterior subcutaneous transposition is performed. The tourniquet is released and hemostasis is performed. The use of a drain is recommended to avoid hematoma formation and is typically removed on postoperative day 1. The fascia is repaired along the medial and lateral columns with care not to tether the triceps tendon. Standard skin closure is performed, and the arm is placed in a posterior splint in approximately 60 degrees of flexion.
POSTOPERATIVE MANAGEMENT

The patient is kept overnight for observation, and the arm is elevated with neurovascular evaluation every 4 hours. The drain is removed on the morning following the surgery, and the patient is discharged home in the posterior splint with instructions to contact the office if he or she notices any numbness, discoloration, or loss of function in the hand and fingers. The patient returns to the office...
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at 2 weeks following the surgery, and the splint is removed. The patient is placed into a removable elbow splint and begins working on gravity-assisted flexion and extension exercises. Six weeks following the osteotomy, x-ray is obtained to look for early signs of healing. The patient is allowed to begin active and active-assisted range of motion and is allowed to use the arm for light activities not lifting anything greater than 1 to 2 lb. A repeat radiograph at 3 months is obtained to confirm healing, and the patient is allowed to begin a strengthening program and can progress to full activity as tolerated by 4 months after the surgery (Fig. 11-I1A and B).

SUMMARY

Cubitus varus is most commonly seen following malunited supracondylar distal humerus fractures. Minor deformities are often cosmetically unappealing but do not result in significant functional deficits. Varus deformity greater than 15 degrees will often lead to functional limitations, ulnar nerve symptoms, lateral ligamentous laxity, and the development of ulnohumeral arthritis. Patients with symptomatic cubitus varus without signs of advanced arthritic changes are candidates for a distal humeral osteotomy.

Distal humeral osteotomy is a technically demanding procedure that requires clear understanding of the patient’s pathologic anatomy as well as the normal anatomy of the elbow. Preoperative planning with the creating of templates using 3D CT scans helps to allow for successful realignment of the extremity. Rigid fixation and compression of the osteotomy are best performed using a parallel plating technique with medial and lateral plates placed with compression of the osteotomy site.

RECOMMENDED READINGS
