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ESSENTIAL SURGICAL TECHNIQUES

SUBSPECIALTY PROCEDURES

Oblique Lateral Closing-Wedge Osteotomy for Cubitus Varus in Skeletally Immature Patients

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Abstract

Background: We perform an oblique lateral closing-wedge osteotomy of the distal end of the humerus to correct cubitus varus deformity in children. This deformity is often the consequence of undertreatment, malreduction, or malunion of supracondylar humeral fractures[1]. Although standard arcs of motion may be altered, cosmesis was traditionally considered a primary surgical indication. However, uncorrected cubitus varus leads to posterolateral rotatory instability of the elbow (PLRI)[2], lateral condylar fractures[3], snapping medial triceps, and ulnar nerve instability[4]. A contemporary understanding of these delayed sequelae has expanded our current indications. Detailed parameters predictive of late sequelae are needed to further specify surgical indications.

Description: We remove an oblique lateral closing wedge from the distal end of the humerus via a standard lateral approach. The osteotomy is angled away from the varus joint line such that lateral cortices after reduction lack prominence. Kirschner wires provide adequate fixation in young patients. In older children, extension is simultaneously corrected, and fragments are stabilized via plate osteosynthesis.

Alternatives: Patients who decline surgery are counseled regarding risks of delaying treatment until symptoms are present. PLRI manifests as lateral elbow pain or instability while rising from a chair. Once symptomatic, the lateral ulnar collateral ligament (LUCL) is irreversibly attenuated and morphologic changes in the ulnohumeral joint necessitate more extensive surgery to include distal humeral osteotomy, LUCL reconstruction, and possibly ulnar nerve transposition[5]. Alternative osteotomy techniques are described and categorized as simple lateral closing wedge, step-cut[6–9], dome, 3-dimensional[10], or distraction osteogenesis. Simple closing-wedge osteotomies include a distal cut parallel to the joint line and retain a problematic lateral prominence (if the medial cortex is intact or the distal end of the humerus is not translated medially)[11,12]. Step-cut osteotomies theoretically minimize this lateral prominence while enhancing inherent stability. However, these additional cuts mandate wide surgical exposure despite similar outcomes[13]. Three-

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dimensional planning employs computed tomography to create expensive anatomic cutting guides that address varus, extension, and internal rotation. However, residual internal rotation is generally well tolerated, derotation is associated with loss of fixation, and the extension deformity will successfully remodel in patients who are <10 years old[14]. We employ 3-dimensional planning in skeletally mature patients with complex deformity and no remodeling potential.

Rationale: The oblique lateral closing wedge is ideal for skeletally immature patients because it is simple, reproducible, and efficient. It avoids the lateral prominence without increasing complexity or complications.

Introductory Statement

The oblique lateral closing-wedge osteotomy to correct cubitus varus is a safe and reproducible option in skeletally immature patients with equivalent outcomes to more complex alternative techniques.

Indications & Contraindications

Indications

- Substantial cubitus varus with potential for late sequelae (a carrying angle exceeding 5° to 10° of varus).
- Skeletal immaturity.
- Age of >5 years (adequate size and compliance); we prefer patients who are 8 to 9 years old if possible.
- One year after inciting trauma or event (plateaued range of motion and remodeling potential).
- Flexion and/or extension deformity is corrected during the procedure in all children ≥10 years old and in children <10 years old if the sagittal plane range-of-motion discrepancy between the affected and the unaffected arm is >10°.
- Appropriate clinical setting (i.e., active patient, cosmetic concerns, asymmetry to unaffected contralateral limb, open physes, etc.).

Contraindications

- Skeletal maturity.

Step-by-Step Description of Procedure

Step 1: Preoperative Planning

Prior to surgery, obtain a detailed geometric assessment of the affected and unaffected extremities of the patient to plan the osteotomy.

- During physical examination (with a goniometer), assess the preoperative range of motion (with specific attention to elbow flexion and extension), the carrying angle of each upper extremity (affected and unaffected), ulnar nerve stability, and the baseline neurovascular status of the limb.
- During radiographic evaluation, assess the carrying angle and Baumann angle of each extremity (affected and unaffected). The planned osteotomy should resect an angle roughly equivalent to the difference between affected and unaffected carrying angles. Note that anteroposterior elbow radiographs (obtained perpendicular to a neutral elbow with the forearm fully supinated) should be critically assessed; flexion or extension deformities of the distal end of the humerus can alter the radiographic carrying angle and should be considered.

Step 2: Template the Osteotomy

Using the anteroposterior elbow radiograph, plan the osteotomy in the coronal plane to accurately correct varus with minimal lateral prominence.

- Using the anteroposterior radiographs, calculate the angle of correction (AOC) by subtracting the carrying angle of the affected arm from the carrying angle of the unaffected arm.
- Draw a V using the AOC as the angle between 2 lines. These lines will represent the proximal (P) and distal (D) osteotomy cuts.
- Place the apex of the V along the medial distal humeral cortex and just above the medial epicondyle. Then slide the apex superiorly or inferiorly along the medial distal humeral cortex until (1) the distal cut is just superior to the olecranon fossa, and (2) the proximal cut length is greater than or equal to the distal cut length (Fig. 1).
- To verify that the lateral prominence will be minimal, ensure that the distal cut is oblique to the pathologic joint line.

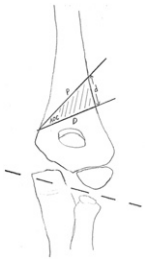

Fig. 1

Fig. 1 Initial template of the osteotomy site. The angle of correction (AOC) in this example is 25°. The pathologic joint surface is noted inferiorly by a dotted line. P = proximal osteotomy, D = distal osteotomy, and d = distance between Kirschner wires designating lateral entry for osteotomy cuts.

Step 3: Surgical Preparation for Osteotomy

After standard upper extremity surgery preparation and exposure, place 0.062-in (1.6-mm) or 0.078-in (2.0-mm) Kirschner wires to guide the osteotomy cuts.

- We prefer supine positioning with the operative elbow centered on a hand table. Locate C-arm fluoroscopy in the axilla, place the monitor near the patient's head, and obtain lateral radiographs via rotation of the humerus or rotation of the C-arm.
- Inflate a tourniquet on the involved extremity. Expose the distal end of the humerus via a longitudinal standard lateral approach between the triceps and the brachioradialis.
- Incise the periosteum longitudinally at the planned osteotomy site and expose bone laterally.
- Perform enough subperiosteal elevation anteriorly and posteriorly in order to place retractors on the bone to the medial side. Maintain the medial periosteal sleeve.
- Under fluoroscopic guidance, position a smooth Kirschner wire at 1 of the planned osteotomy sites (proximal or distal) from lateral to medial. We prefer to place the distal Kirschner wire first.
- Place the second smooth Kirschner wire as follows:
  - Place the tip of the second Kirschner wire centered on the lateral cortex at a premeasured distance (d) from the first Kirschner wire (Fig. 1).
  - Using a sterile goniometer, angle the second Kirschner wire in the same coronal plane according to the AOC using the first Kirschner wire as a reference.
  - Drill the second Kirschner wire from lateral to medial just beyond the medial cortex (note the location of the ulnar nerve).
- Place 2 smooth, slightly divergent 0.062-in (1.6-mm) to 0.078-in (2.0-mm) Kirschner wires retrograde through the lateral column in a near vertical trajectory, stopping short of the planned distal cut (Fig. 2). The larger Kirschner wires are preferred in patients >5 to 6 years old.

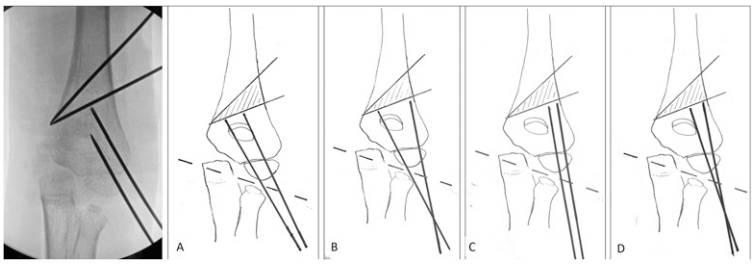

Fig. 2

Fig. 2 Fluoroscopic and artistic images of retrograde Kirschner wire placement. The location and trajectory of these Kirschner wires should be planned in order to allow placement of a third pin: laterally (**Fig. 2-A**), between provisional Kirschner wires (**Fig. 2-B**), or medially (**Figs. 2-C and 2-D**). The pathologic joint surface is noted inferiorly by a dotted line. We prefer the option in Figures 2-A or 2-B.

Step 4: Perform the Osteotomy

Perform the osteotomy.

- Use an oscillating saw (or straight osteotome) to perform the osteotomy cuts along the inside of the proximal and distal Kirschner wires. Ensure that the oscillating saw is perpendicular to the anatomic axis of the distal end of the humerus so as not to induce flexion or extension.
- Leave a small medial cortical hinge to preserve the medial periosteum and avoid the ulnar nerve.
- If the patient is >10 years old, we plan to correct hyperextension by rotating and flexing the proximal cut to close the osteotomy anteriorly[14] (Fig. 3). The flexion angle (θ) is obtained by subtracting the terminal passive extension of the affected extremity from that of the unaffected extremity. Instead of making the proximal cut parallel (black dotted line) to the distal cut (black line), score the lateral cortex (red line) and verify that the flexion angle (θ) is correct before completing the cut. The flexion angle is not usually large enough to add excessive shortening.
- Remove the proximal and distal osteotomy guidewires.

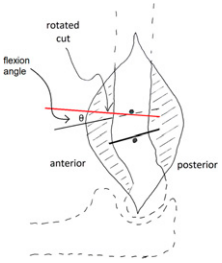

Fig. 3

Fig. 3 Proximal cut rotation to correct hyperextension deformity in children >10 years old. The osteotomy cuts are depicted from a lateral view inside their respective proximal and distal Kirschner wires. In children <10 years old, the proximal cut (black dotted line) would be parallel to the distal cut (solid black line), both of which are perpendicular to the anatomic axis of the distal end of the humerus. The flexed cut (red line) creates an anterior closing wedge at the desired flexion angle (θ). The flexion angle (θ) is obtained by subtracting the terminal passive extension of the affected extremity from that of the unaffected extremity.

Step 5: Correct the Deformity (Fig. 4 and Video 1)

Achieve appropriate reduction and fixation of the osteotomy site.

- In order to reduce the osteotomy site, gently flex the elbow and pronate the forearm as if treating a supracondylar humeral fracture. The intact medial cortex may audibly crack.
- Confirm the reduction on both anteroposterior and lateral fluoroscopy.
- Drill the prepositioned lateral column Kirschner wires across the osteotomy site and into the medial cortex of the proximal fragment.
- Confirm the reduction and fixation via the lateral surgical exposure.
- Add a third divergent lateral-entry Kirschner wire for increased stability (Fig. 5).
- Irrigate and close the surgical wound with the elbow flexed 90°.
- Cut and bend the Kirschner wires and leave outside the skin.
- Apply sterile dressings.

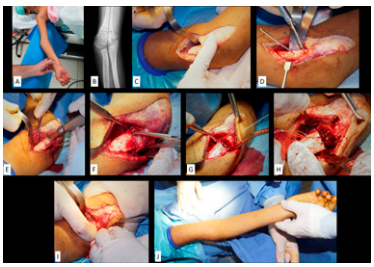

Fig. 4

Fig. 5

Figs. 4-A through 4-J Intraoperative photographs of an 11-year-old child with a prior right supracondylar humeral fracture treated nonoperatively. (Reproduced from: Kozin SH. Bone fixation. In: Chang J. Global reconstructive surgery. 1st ed. New York: Elsevier; 2019. p 77-85. Reproduced with permission from Elsevier.) **Fig. 4-A** Clinical examination demonstrates cubitus varus (gunstock deformity). **Fig. 4-B** The right elbow anteroposterior radiograph. **Fig. 4-C** Through a standard lateral incision along the supracondylar ridge of the distal end of the humerus, the brachioradialis and extensor carpi radialis muscles are elevated and anterior subperiosteal dissection continues under the brachialis to the medial side of the humerus. **Fig. 4-D** Proximal and distal pins are drilled from lateral to medial at the sites of the planned osteotomy. **Fig. 4-E** An oscillating saw is utilized to perform the osteotomy cuts from lateral to medial. A medial cortical hinge is preserved. Osteotomes may be used to complete the cut. **Fig. 4-F** The lateral closing wedge of bone is removed. The medial cortex is preserved. The pins at each osteotomy site are removed. **Fig. 4-G** Large parallel or divergent Kirschner wires are placed percutaneously up the lateral column into the distal aspect of the osteotomy. **Fig. 4-H** The medial cortex is cracked, and the osteotomy is reduced without lateral prominence. **Fig. 4-I** The percutaneous lateral column pins are advanced across the osteotomy site and into the proximal medial cortex with fluoroscopic confirmation. **Fig. 4-J** Limb alignment is assessed before standard closure and application of a long arm cast.
Figs. 5-A and 5-B Osteotomy reduction with fixation and addition of a third lateral-entry Kirschner wire. **Fig. 5-A** A third Kirschner wire was added laterally to the option in Figure 2-A. Follow-up radiographs made after 1 year demonstrate a well-aligned and healed osteotomy. **Fig. 5-B** A third Kirschner wire is added between provisional Kirschner wires in Figure 2-B.
Video 1 Oblique lateral closing-wedge osteotomy for cubitus varus, including a Sawbones demonstration, surgical exposure, osteotomy preparation, execution, reduction, and fixation.

Step 6: Postoperative Care

Immobilize the extremity to allow osseous healing and then shift focus to optimize postoperative range of motion.

- Apply a bivalved long arm cast in 90° of elbow flexion and neutral forearm rotation.
- At postoperative week 1, check anteroposterior and lateral elbow radiographs and overwrap the cast.
- At postoperative week 4, remove the pins. If radiographs demonstrate adequate callus (i.e., periosteal callus bridging 3 cortices), discontinue the cast. If callus is less than desired, manage with a cast for 2 additional weeks.
- Prescribe a sling for comfort between weeks 4 and 6 and initiate active range of motion.
- At postoperative week 8, consider physical therapy for stiffness if range of motion plateaus.

Results

In a previously reported series of 23 patients averaging 9.5 years old and with an average of 3.4 years of follow-up, 92% of patients had an excellent result and none had a lateral prominence[15]. The humerus-elbow-wrist angle averaged −18.5° preoperatively and improved to 11.7° postoperatively. There were 3 pin-site infections, which resolved without surgery. North et al. reported a series of 90 consecutive patients over a 27-year period who had correction with a similar technique and achieved similarly satisfying results[16]. They quantified the lateral condylar prominence index to be an average of +0.14 (almost normal) at the time of the final follow-up.

The most common variations to our technique usually differ in fixation or surgical approach. We start to consider plate fixation (rather than Kirschner wires) via a posterior approach in children who are >12 years old, although this is controversial[17,18] (Fig. 6). Authors concerned about fixation or infection have suggested using buried threaded pins across the osteotomy site, although this requires a second anesthetic for removal. A posterior approach is associated with a higher prevalence of nerve palsies but may be necessary when a more anatomic correction in older patients is desired[17].

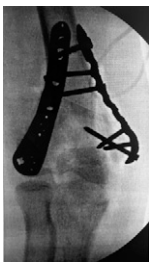

Fig. 6

Fig. 6 Orthogonal medial and lateral column plate fixation via a posterior triceps-sparing approach was performed (after provision fixation with 2 Kirschner wires as described above) in a 13-year-old patient. Fluoroscopic images clearly demonstrate the osteotomy location.

Pitfalls & Challenges

- During lateral exposure, the radial nerve should be >6 cm from the distal humeral physis in children who are >6 years old and closer in younger children[19].
- Ensure that the distal cut is planned oblique from the pathologic joint line to avoid the traditionally problematic lateral prominence.

- The templating rules detailed in Step 2 are critical to ensure both accurate deformity correction and minimal lateral prominence. If too much lateral prominence is present after the osteotomy is reduced, destabilize the medial cortex (by completing the osteotomy) and translate the osteotomy medially. Maintain control of the distal fragment with an adequately sized (consider using at least one 2.0-mm) prepositioned Kirschner wire during this maneuver.
- During the osteotomy reduction maneuver (Step 5), be prepared to swing the fluoroscopic arm from an anteroposterior to a lateral position without manipulating the arm or losing control of the osteotomy reduction prior to fixation.

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