Proximal Humeral Fracture Repair and Rehabilitation

Surgical Indications and Considerations

Anatomical Considerations: Numerous types of proximal humeral fractures can occur each of which have separate surgical indications and considerations. Proximal humeral fractures commonly occur along the physeal lines. Thus, fractures may involve the tubercles (greater and/or lesser), surgical neck, or anatomical neck of the humerus. The surgical neck lies between the tuberosities and the shaft while the anatomical neck is the junction between the humeral head and the tuberosities. Fortunately, surgical neck fractures are more common. Anatomical neck fractures typically have a less favorable prognosis due to their result in devascularization of the humeral head. Between the two tuberosities of humerus lies a groove in which the biceps tendon lies. It is through this groove that the terminal branches of the ascending division of the anterior humeral circumflex artery enter the humeral head. Fractures that split the tuberosities from the head disrupt this small arterial complex and can result in osteonecrosis of the humeral head.

The most recognized and used standard for assessing proximal fractures is the 4-part Neer classification system. It is used for both treatment and prognosis.

The 4-part classification:

One-part fractures
Eight of ten proximal humeral fractures are of this type and include all fractures of the proximal humerus, regardless of the level or number of fracture lines, in which no segment is displaced more than 1cm or angulated more than 45°.
Two-part fractures
The two-part fracture includes those proximal humeral fractures with a single displacement at the anatomic neck, surgical neck, lesser tuberosity, or greater tuberosity. The fracture is named by the structure that is displaced (Two-part surgical neck fracture).
Three-part fractures
The three-part fracture includes all proximal humeral fractures with a displaced surgical neck and either a greater or lesser tuberosity displacement fracture.
Four-part fractures
Four-part fractures are proximal humeral fractures with three displaced, fractured segments including both tuberosities and typically the surgical neck. Avascular necrosis is common in these types of fractures.

The anatomical positioning of the neural and vascular structures of the arm can cause complications in these types of fractures. Severe displacement of the structures of the shoulder with these types of injury can cause damage to the brachial plexus (most commonly a traction injury of the axillary nerve) or vascular structures (commonly effecting the axillary artery). Avascular necrosis is also a complication causing bone cell death when the blood supply is cut off from a fractured region of bone as mentioned above.

Pathogenesis: Bone fractures when the mechanical forces exceed the physiologic capacity of the bone. Intrinsic weakening of bone increases the risk of such pathology. Weakening of proximal humeral bone tissue may occur due to repetitive stress (as occurs in little leaguer's shoulder and stress fractures), endocrine functioning (as is the case in osteoporosis), pathology (such as sickle cell anemia, tumors, or cancer), or nutritional deficits (as found in cases of Rickets and osteomalacia). External forces commonly leading to proximal humerus fractures include a fall on the outstretched arm, excessive rotation in the abducted position, a direct blow to the lateral aspect of the shoulder, dislocation leading to subsequent avulsion fracture(s), electrical shock, and muscular forces of seizures (subscapularis can avulse the lesser tuberosity).

Biomechanically with a fall on the outstretched arm, the most common cause of proximal humeral fractures, the shoulder and limb remain medially rotated. Normally, to accomplish full abduction, the humerus must externally rotate. If external rotation is blocked, as in a fall, the proximal humerus becomes impinged against the acromion. The acromion acts as a fulcrum of a lever and the depending on the quality of the tissues of the shoulder complex the humerus may fracture, dislocate, or both dislocate and fracture.

Epidemiology: Proximal humeral fractures are relatively common. They represent about 4% of all fractures seen in the average orthopedic clinic. These fractures occur in all ages but are most common in relatively fit elderly. The injury is more common in females and the highest age-specific incidence occurs in women between 80 and 89 years of age. Not surprisingly these injuries are more commonly caused by sport and road traffic accidents in younger generations, while over the age of 30 the chief cause of proximal humeral fractures is a "standing height" fall. ~49% of proximal humeral fractures are part-one, ~28% are part-two surgical neck fractures, ~9% are three-part greater tuberosity and surgical neck fractures. Four-part fractures and fracture dislocations account for ~3% of proximal humeral fractures.

Diagnosis

- Mechanism of injury is usually consistent with a fall on an out stretched arm or blow to the shoulder during a traumatic or sports related event
- Severe point tenderness over the fracture site can be found with palpation, caution should be used to prevent further damage at the fracture site
- Swelling usually appears immediately about the shoulder and upper arm while ecchymosis generally appears 24-48 hrs later. Ecchymosis may spread to the chest wall, flank, and forearm.
- Confirmation of the fracture can be made with radiographic images.
- CT scan is indicated in selected cases.

Non-operative Versus Operative Management: Treatment of proximal humeral fractures vary depending on the type and severity of the fracture as well as the activity level, health, age, quality of bone, and motivation of the patient. Generally, most unstable/displaced fractures or fractures with accompanying vascular insult require surgical intervention. Various methods of treatment include closed reduction, casts, splints, percutaneous pinning, external fixation, open reduction and internal fixation, and humeral head replacement.

Non-operative:
Non-displaced or minimally displaced fractures as well as patients with medical illnesses that preclude them from surgery should be treated conservatively. They can be managed non-surgically, by immobilizing the arm in a sling for comfort and instituting early range of motion exercises when pain permits. See protocol for treatment below.

Operative:
Isolated two-part fractures of the tuberosities are difficult to perform closed reduction on secondary to the forces created by the attached rotator cuff muscles. The greater tuberosity fracture is treated nonoperatively for fractures with less than .5 cm of superior displacement or 1cm of posterior displacement. If greater, these fractures are generally treated with open reduction internal fixation to prevent subacromial impingement and malunions. The rare isolated lesser trochanteric fracture is treated with open reduction internal fixation when the fragment is large and blocks medical rotation.

Two-Part Surgical Neck Fractures are generally treated with open reduction internal fixation for younger patients with good bone quality and ability to comply with postoperative therapy. Rigid internal fixation devices often fail when applied to thin porous bone so hemiarthroplasty is often a better treatment choice for elderly patients. Percutaneous internal fixation is often chosen for displaced two-part fractures that can be reduced with closed manipulation. Intramedullary fixation has been completed successfully by some but concern of torsional rigidity, risk of displacement, and impingement by a prominent rod deters many from this technique.

Three part fractures also have multiple treatment choices including internal fixation options of interfragmentary fixation with sutures or wire, percutaneous pinning, plate-and-screw fixation, and intramedullary fixation with and without suture supplementation. Reduction can be completed closed but are difficult to manage. Open reduction is the more common management. Rarely, prosthetic hemi-arthroplasty is used.

Four-part fracture treatment options range from early mobilization to percutaneous reduction and internal fixation, open reduction and internal fixation, and hemiarthroplasty. Nonoperative treatment is typically reserved for those in which surgery is contraindicated secondary to the fact that this treatment often results in malunion and pain. There is conflicting evidence recorded on the most effective treatment for this injury.

NONOPERATIVE AND POSTOPERATIVE REHABILITATION

Note: The following rehabilitation progression is a summary of the guidelines provided by Basti, Dionysian, Sherman, and Bigliani. Refer to their publication to obtain further information regarding criteria to progress from one phase to the next, anticipated impairments and functional limitations, interventions, goals, and rationales.

REHABILITATION FOR NON-OPERATIVE HUMERAL FRACTURES

Early Passive Motion: (7-10 days post fracture)

Goals: Control pain and edema
Protect fracture site
Minimize deconditioning
Maintain range in joints around the effected region (wrist, hand, and neck)
Prevent glenohumeral adhesive capsulitis and muscle flexibility deficits

Intervention:

- Modalities, such as TENS and ice, for pain control
- Splint/Sling as direct by MD
- Monitor use and weight bearing instructions per MD
- Cardiovascular conditioning
- Gentle range of motion exercises of the neck, wrist, and hand
- Pendulum exercises
- Passive forward elevation of the shoulder
- Passive external rotation of the shoulder

Early Passive Motion: (10 days to 3 weeks post fracture) When pain has diminished and the patient is less apprehensive.

Goals: Same as above

Intervention: in addition to above

- Active assistive forward elevation
- Active assistive external rotation to 40°

Phase I: (3-6 weeks post fracture)

Goals: Continue to control pain and edema as needed
Minimize deconditioning
Regain full range of motion
Prevent muscle atrophy

Intervention:

- Pendulum
- Active assistive forward elevation
- Active assistive external rotation
- Isometrics: Internal and external rotation, flexion, extension, and abduction in a neutral position (at 4 weeks)
- Active assistive hyper extension (at 6 weeks)
- Gripping exercises

Phase II: (6-8 weeks post fracture)

Goals: Regain full Range of motion
Actively work within newly gained range of motion
Increase strength

Intervention:

- Active forward elevation in supine
- Active forward elevation with weights in supine
- Forward elevation in standing with stick
- Pulleys with eccentric lowering of involved arm

Phase III: (8 weeks post fracture)

Goals: Increase strength (especially at end range)
Gain adequate strength in the rotator cuff to allow for humeral head depression necessary to avoid impingement
Strengthen scapular rotators to allow for proper scapulohumeral rhythm

Intervention:

- Resistive exercises: standing forward press, theraband resisted (flexion, internal rotation, external rotation and abduction) exercises, and rowing
- Self stretching: flexion/abduction combined, internal rotation, flexion, abduction/external rotation combined, bilateral hanging stretches
- Advanced internal rotation, shoulder flexion, external rotation and horizontal abduction stretching

REHABILITATION FOR OPEN REDUCTION/INTERNAL FIXATION AND HUMERAL HEAD REPLACEMENT

Preoperative Rehabilitation

- Injury is protected with immobilization through casting, splinting and/or placed in a sling
- Patient is instructed of post-operative rehabilitation goals and plan

Early Passive Motion: (3-5 days post op)

Goals: Control pain and edema
Protect fracture site
Minimize cardiovascular deconditioning
Maintain range in joints around the effected region (wrist, hand, and neck)
Prevent glenohumeral adhesive capsulitis and muscle flexibility deficies

Intervention:

- Modalities, such as TENS and ice, for pain control
- Splint/Sling as direct by MD
- Monitor use and weight bearing instructions per MD
- Cardiovascular conditioning
- Gentle range of motion exercises of the neck, wrist, and hand
- Passive supine external rotation to 40°
- Passive supine forward elevation

Phase Ia: (7-10 days post op) and **Phase Ib:** (3 weeks post op)

Goals: Continue to control pain and edema as needed
Minimize deconditioning
Regain full range of motion
Prevent muscle atrophy

Intervention: Phase Ia

- Pendulum
- Passive external rotation with stick or pulleys
- Passive forward elevation with assist from non involved arm or pulleys
- Passive internal rotation and hyperextension with stick (not to be done with tuberosity fracture)
- Cardiovascular conditioning

Interventions: Phase Ib

- Isometrics: Internal rotation, external rotation, flexion, extension, abduction in a neutral position

Phase II: (4-6 weeks post op)

Goals: Regain full Range of motion
Actively work within newly gained range of motion
Increase strength

Intervention:

- Active forward elevation in supine
- Active forward elevation with weights in supine
- Forward elevation in standing with stick
- Pulleys with eccentric lowering of involved arm

Phase III: (12 weeks post op)

Goals: Increase strength (especially at end range)
Gain adequate strength in the rotator cuff to allow for humeral head depression necessary to avoid impingement
Strengthen scapular rotators to allow for proper scapulohumeral rhythm

Intervention:

- Resistive exercises: Standing forward press, theraband resisted (flexion, internal rotation,
  external rotation and abduction) exercises, and rowing
- Self stretching: flexion/abduction combined, internal rotation, flexion, abduction/external rotation
  combined, bilateral hanging stretches
- Advanced internal rotation, shoulder flexion, external rotation and horizontal abduction
  stretching

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