Proximal Humeral Fractures: What an Emergency Radiologist Needs to Know

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Objectives

- Learn the epidemiology of proximal humeral fractures
- Understand the fracture patterns with major emphasis on the Neer classification system
- Identify associated injuries
- Learn the various treatment options
- Identify common surgical complications
Epidemiology

• Proximal humerus fractures account for 4-5% of all fractures \(^1,2\)
  – 71% of these occur in patients over the age of 60 \(^3,4\)
  – High-energy trauma is the most common cause in patients younger than age 50 while minimal to moderate trauma is the most common cause in patients older than age 50 \(^5\)
  – The majority of fractures are nondisplaced or minimally displaced, allowing for conservative management
Neer Classification

- Most commonly used classification system for proximal humeral fractures
- Developed in 1970 and updated in 2002
- Based on:
  - Anatomic relationship of 4 “parts” of the proximal humerus (defined by Codman in 1934)
    - Greater tuberosity
    - Lesser tuberosity
    - Articular surface component
    - Humeral shaft
    - “Part” is considered displaced if: >1cm separation or >45 degree angulation
  - Glenohumeral dislocation
  - Articular surface involvement
- Moderate interobserver reliability (kappa value): 0.21-0.64
- Good intraobserver reliability: 0.5-0.8

* The above chart was created by the author.
One Part

• “Parts” do not meet criteria for displacement regardless of the number of fracture lines or involved “parts”
• Accounts for approximately 75% of proximal humeral fractures
• Comprises category 1

* The above chart was created by the author.
Left shoulder radiographs of a 66 year old man demonstrate a nondisplaced fracture of the greater tuberosity (⊕) with extension into the glenohumeral joint (▷).
Axial and coronal CT images better delineate the fracture lines. Given the lack of displacement, this is consistent with a **one part fracture** regardless of the number or location of involved parts.
One Part CT 3D
### Two Part

- One “part” is displaced
- There may be superimposed glenohumeral dislocation
- Accounts for approximately 20% of proximal humeral fractures
- Comprises categories 2 to 7

* The above chart was created by the author.
Right shoulder radiographs of an 88 year old woman demonstrate a displaced, overriding, oblique fracture at the surgical neck (>). Fracture lucency is also seen along the greater tuberosity (+).
Axial and coronal CT images better delineate the surgical neck fracture with displacement and overriding of the humeral shaft. Although the fracture line extends into the greater tuberosity, there is no significant displacement or angulation. Findings are consistent with a two part fracture.
Two Part CT 3D
Three Part

- Two “parts” are displaced
  - Fracture commonly involves one of the tuberosities and the surgical neck
  - The remaining intact tuberosity may produce a rotational deformity of the articular component
- There may be superimposed glenohumeral dislocation
- Accounts for approximately 5% of proximal humeral fractures
- Comprises categories 8 to 11

* The above chart was created by the author.
Left shoulder radiographs of a 64 year old woman demonstrate a comminuted, displaced fracture of the greater tuberosity (+).
Axial and coronal CT images better delineate the comminuted, displaced greater tuberosity fracture. Also, there is a displaced surgical neck fracture, not clearly seen on the radiographs. The lesser tuberosity is intact. Findings are consistent with a three part fracture.
Four Part

- All four “parts” are displaced
- Articular surface component is typically displaced laterally and out of contact with the glenoid
- High risk of avascular necrosis (AVN)
- Accounts for <1% of proximal humeral fractures
- Comprises categories 12 to 14

* The above chart was created by the author.
Right shoulder radiographs of a 64 year old man demonstrate comminuted, displaced fracture fragments (+) adjacent to the glenoid, likely arising from the greater and/or lesser tuberosity. There is anterior dislocation of the glenohumeral joint.
Axial and coronal CT images delineate that the comminuted fracture fragments originate from both greater and lesser tuberosities. Also, a displaced surgical neck fracture is seen, which was not clearly demonstrated on the radiographs. Findings are consistent with a four part fracture with anterior dislocation.
Four Part CT 3D
Articular Surface Fractures

• Head-splitting
  – Commonly splits the articular surface into two or more fragments
  – Category 15

• Impaction
  – Involves >40% articular surface
  – Most often associated with chronic dislocation
  – Category 16

* The above charts were created by the author.
Left shoulder radiographs of a 51 year old woman demonstrate a severely comminuted fracture of the proximal humerus, involving the articular surface and both tuberosities.
Axial and coronal CT images better delineate an essentially shattered proximal humerus. There is also an impaction fracture of the glenoid. Although this case does not perfectly fit into head-splitting or impaction fracture categories, the fracture clearly involves a significant portion of the articular surface.
Articular Surface Fracture
Four Part with Valgus Impaction

- Neer added this pattern as a separate category in 2002 due to different prognosis and treatment
- Head is rotated into a valgus posture and driven down between the tuberosities, which splay out to accommodate the head
- Unlike the classic four-part fracture, the articular surface is not laterally displaced and vascularity is preserved (lower risk of avascular necrosis)
- Comprises category 17

* The above chart was created by the author.
Other Classification Systems

• Arbeitsgemeinschaft fur Osteosynthesefragen (AO) / Orthopaedic Trauma Association (OTA) classification
  – Based on the vascular supply to the humeral head
  – Developed in 1990 and updated in 2007
  – More complex than the Neer classification system, yet there is no evidence that it is more reliable
  – Advantages: varus/valgus distinction, important for prognostic and therapeutic purposes
  – Disadvantages: lack of clear criteria for displacement
Associated Injuries

- Avascular necrosis
  - Best predictors:
    - Short calcar segment (also known as metaphyseal head extension)
      - <8mm $^{11,12}$
    - Displaced medial hinge
      - Defined as the pivot point of the head at the level of the posteromedial fracture line
      - >2mm $^{11,12}$
    - Anatomic neck fracture
      * If all three are present, 97% positive predictive value $^{12}$

* The above charts were created by the author.
Associated Injuries

• Rotator cuff tear
  – Rarely associated with proximal humeral fractures. Therefore, MRI is not routinely performed for the workup of proximal humeral fractures

• Neurovascular injury
  – Brachial plexus and axillary artery injuries are rare 13
  – Prospective study of 49 patients with four part fracture by Stableforth showed 4.9% incidence of vascular injury and 6.1% incidence of brachial plexus injury 14
Management

- One part
  - Most often conservative management
  - If anatomic neck is fractured:
    - Young patient: open reduction internal fixation (ORIF)
    - Elderly/osteoporotic patient: ORIF or hemiarthroplasty

- Two part
  - Closed reduction and conservative management if possible
  - Surgical neck (85%)
    - Closed reduction percutaneous pinning (CRPP)
    - ORIF with locking plate
    - Intramedullary (IM) rod placement
  - Greater tuberosity
    - Young patient: CRPP
    - Elderly/osteoporotic patient: ORIF with nonabsorbable suture or tension band wiring
  - Lesser tuberosity
    - Large fragment: ORIF
    - Small fragment: excision with rotator cuff repair
  - Anatomic neck
    - Young patient: ORIF
    - Elderly/osteoporotic patient: ORIF or hemiarthroplasty
Management

- **Three part**
  - Young patient: CRPP, IM rod placement, ORIF
  - Elderly/osteoporotic patient: hemiarthroplasty with rotator cuff repair or tuberosity repair

- **Four part and articular surface fractures**
  - Young patient: ORIF preferred. Hemiarthroplasty if patient has nonreconstructable articular surface or extruded anatomic neck fracture
  - Elderly/osteoporotic patient: hemiarthroplasty

- **Valgus impacted four part**
  - ORIF

- **Additional operative management**
  - Reverse shoulder arthroplasty: in elderly patients with nonreconstructable tuberosities or rotator cuff tear
  - Total shoulder arthroplasty: glenoid surface injury with intact rotator cuff
Surgical Complications

- Avascular necrosis
- Neurovascular injury
  - Axillary and suprascapular nerve
  - Axillary artery and its branches
- Malunion or nonunion
- Rotator cuff injury
- Infection
Proximal humeral fractures are commonly encountered in the emergency department. Neer classification is the most widely used approach to fracture description. While radiographs and CTs are frequently used in the setting of proximal humeral fractures, MRI is rarely used. Avascular necrosis of the humeral head is associated with short calcar segment, displaced medial hinge, and anatomic neck fracture. Neurovascular injury is rarely caused by the fracture itself but is more frequently encountered as a surgical complication. Management of proximal humeral fractures depends on many factors including patterns of fracture and/or dislocation, patient’s age, and bone density.
Neer classification has a total of 17 categories based on:

- Anatomic relationship of “parts”
- Glenohumeral dislocation
- Articular surface involvement

* The above charts were created by the author.
References