Proximal Humerus Fractures: Evaluation and Management in the Elderly Patient

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Abstract

Introduction: Proximal humerus fractures are common in the elderly. The evaluation and management of these injuries is often controversial. The purpose of this study is to review recent evidence and provide updated recommendations for treating proximal humerus fractures in the elderly. Methods: A literature review of peer-reviewed publications related to the evaluation and management of proximal humerus fractures in the elderly was performed. There was a focus on randomized controlled trials and systematic reviews published within the last 5 years. Results: The incidence of proximal humerus fractures is increasing. It is a common osteoporotic fracture. Bone density is a predictor of reduction quality and can be readily assessed with anteroposterior views of the shoulder. Social independence is a predictor of outcome, whereas age is not. Many fractures are minimally displaced and respond acceptably to nonoperative management. Displaced and severe fractures are most frequently treated operatively with intramedullary nails, locking plates, percutaneous techniques, or arthroplasty. Discussion: Evidence from randomized controlled trials and systematic reviews is insufficient to recommend a treatment; however, most techniques have acceptable or good outcomes. Evaluation should include an assessment of the patient’s bone quality, social independence, and surgical risk factors. With internal fixation, special attention should be paid to medial comminution, varus angulation, and restoration of the calcar. With arthroplasty, attention should be paid to anatomic restoration of the tuberosities and proper placement of the prosthesis. Conclusion: A majority of minimally displaced fractures can be treated conservatively with early physical therapy. Treatment for displaced fractures should consider the patient’s level of independence, bone quality, and surgical risk factors. Fixation with percutaneous techniques, intramedullary nails, locking plates, and arthroplasty are all acceptable treatment options. There is no clear evidence-based treatment of choice, and the surgeon should consider their comfort level with various procedures during the decision-making process.

Keywords

upper extremity surgery, geriatric trauma, fragility fractures, trauma surgery, osteoporosis

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heads have a diameter between 4 and 5 cm, and the head is slightly offset medially and posteriorly in relation to the humeral shaft.\textsuperscript{9} The pectoralis major tendon inserts 5 to 6 cm from the top of the humeral head, which is a reliable tool for estimating prosthetic stem length in severe fractures without landmarks. Humeral shortening greater than 1 cm can impair deltoid function, whereas humeral lengthening and retroversion can impair tuberosity healing.\textsuperscript{10}

Tendons produce reliable deforming forces on bone fragments. The supraspinatus and teres minor insert on the greater tuberosity and produce a posterosuperior deformity. The subscapularis inserts on the lesser tuberosity and produces medial deformity. The pectoralis major inserts into the medial humeral shaft and deforms medially, while the deltoid inserts into the lateral humerus and deforms laterally (Figure 1).\textsuperscript{6}

The proximal humeral blood supply is from the anterior and posterior humeral circumflex branches of the axillary artery, which are closely associated with the surgical neck and medial calcar (Figure 2). The arcuate artery is the terminal, ascending branch of the anterior humeral circumflex artery and enters the humeral head near the anatomic neck.\textsuperscript{6,11} Fractures with short calcar fragments (<8 mm), a disrupted medial hinge, and anatomic neck involvement are most prone to ischemia.\textsuperscript{12} Gross axillary artery injury is exceedingly rare; however, in cases of significant shoulder trauma with a loss of Doppler signals and an enlarging axillary mass, vascular surgery should be consulted and a computed tomography angiogram ordered. More than 90\% of the reported cases occur in patients 50 years and older, possibly due to the loss of elasticity secondary to atherosclerosis.\textsuperscript{13}

Some degree of electromyographically detectable axonal loss occurs in 67\% of patients with low energy proximal humerus fractures. The most commonly injured nerves in descending order are the axillary, suprascapular, radial, musculocutaneous, median, and ulnar nerves. These are most commonly traction injuries that fully recover.\textsuperscript{14} During surgery, the axillary nerve can be difficult to identify, particularly in scarred shoulders. It is about 4.5 to 7 cm from the proximal humerus and 0.5 to 4 cm from the surgical neck,\textsuperscript{15} traveling through the quadrilateral space with the posterior humeral circumflex artery. Care should be taken with incisions greater than 5 cm in length distal to the acromion. With anterolateral plating, the axillary nerve is most frequently in danger when placing screws near the surgical neck through the middle segment of the plate.\textsuperscript{16}

**The Neer Classification**

The Neer classification for proximal humerus fractures is based on 4 fracture parts: the greater tuberosity, the lesser tuberosity, the humeral head, and the humeral shaft. A full description of the classification and its subtypes can be found in an article by Carofino and Leopold.\textsuperscript{17} For practical purposes, fractures are discussed based on the number of Neer parts involved. A fragment is considered displaced if it is separated more than 1 cm or angulated more than 45\textdegree; however, there is no evidence-
based indication for this definition of displacement. The Neer classification has shown moderate rater reliability. Outcomes and rates of rotator cuff injury correlate with the classification.\textsuperscript{18}

**Evaluation and General Considerations**

The typical presentation of a proximal humerus fracture is an elderly female who falls and sustains a minimally displaced or 2-part fracture (Figure 3). Around 1 in 10 will present with an

![Figure 3. Anteroposterior views of 3 shoulders demonstrating the most commonly encountered fracture patterns: minimally displaced (left) and surgical neck fractures (middle, right) with variable impaction and comminution.](image)

![Figure 4. Anteroposterior views of the shoulder demonstrating the Tingart and DTI methods for measuring bone density. An explanation is provided in the table. DTI denotes deltoid tuberosity index.](image)
additional fracture. Important historical elements include the patient’s level of independence, functional demands, and any preexisting rotator cuff conditions. Evaluation should begin with inspection of the soft tissues and skin, as elderly patients are susceptible to poor wound healing. A full neurologic examination can be difficult following trauma, but function of the fingers, wrist, and elbow can often be evaluated. Axillary nerve innervation of the deltoid needs to be tested as reverse shoulder arthroplasty (RTSA) is a viable treatment option that requires an intact and innervated deltoid.

True anteroposterior (AP), lateral, and axillary X-rays of the glenohumeral joint should be ordered. Computed tomography is recommended for complex fracture patterns or when fracture lines cannot be clearly visualized. Magnetic resonance imaging (MRI) may be useful for assessing rotator cuff integrity when considering nonoperative treatment. In a prospective study of 30 patients, nearly 40% of proximal humerus fractures were associated with rotator cuff tears. In another MRI cohort study of 76 patients with proximal humerus fractures, 22 had cuff tears at the time of injury, and 10 developed tears at 1 year. Functional loss correlated with tears at the time of injury.

Bone density is a predictor of surgical reduction quality and screw cutout. Density can be assessed with cortical bone thickness measurements on AP views of the shoulder. Two techniques are detailed in Figure 4: the Tingart measurement and the deltoid tuberosity index. Bone quality and social independence can serve as indicators of physiologic age, which is more important than chronologic age when weighing treatment options. Several studies have shown no difference in outcomes between elderly patients and younger patients following surgical fixation of proximal humerus fractures. Further, a 1-year outcome study of 637 proximal humerus fractures showed that social independence, not age, was a predictor of outcome.

**Management**

Treatment of proximal humerus fractures is controversial. A 2012 Cochrane review of 23 randomized controlled trials concluded there is insufficient evidence to provide recommendations. There is significant heterogeneity among studies, so making conclusions is difficult. In general, minimally displaced fractures, poor surgical candidates, and low demand patients are treated conservatively. Displaced, comminuted, or angulated fractures occurring in good surgical candidates are treated with percutaneous techniques, intramedullary nailing, plating, or arthroplasty.

**Minimally Displaced Fractures**

Around 50% to 65% of all proximal humerus fractures are minimally displaced fractures of the greater tuberosity and/or surgical neck that respond well to nonoperative management. The shoulder should be placed in a sling followed by early physical therapy. Isometric, pendulum, or passive range of motion exercises should be started within a few days of injury. The sling can be worn until healing is evident, which usually occurs by 4 to 6 weeks. Around this time, active strengthening exercises can begin. Recently, a study by Clement et al included 211 minimally displaced proximal humerus fractures in patients aged 65 to 98. At 1 year, the mean Constant-Murley score was 68.8 (greater than 55 was considered an acceptable outcome).

**Two-Part Surgical Neck Fractures**

Approximately 20% to 30% of proximal humerus fractures are 2-part surgical neck fractures. Many of these patients will respond acceptably to nonoperative management, which should be considered in osteoporotic patients with high physiologic age, low demand, and minimal displacement. Surgery can be considered for fractures with significant displacement and patients with acceptable bone quality.

**Percutaneous techniques.** A retrospective 2015 study by Tamimi et al compared functional outcomes among conservative treatment, nailing, percutaneous wiring, and plating. Percutaneous wiring was associated with superior outcomes in elderly patients, with a mean Constant score of 68.7. Percutaneous wiring generally utilizes a starting point just above the deltoid insertion, where 2 threaded wires are directed proximally into the humeral head. Next, using a starting point on the greater tuberosity, 2 additional threaded wires are directed distally into the humeral shaft (Figure 5). Nonthreaded wires can be used to manipulate the fracture site prior to fixation with threaded wires. Specific techniques are described for valgus angulated fractures by Seyhan et al and varus angulated fractures by Eid et al. Although
technically demanding, the results are excellent with Constant-Murley scores of 90 to 94 at 1 to 3 years of follow-up.

The Humerus Block (Synthes, Oberdorf, Switzerland) is a relatively new percutaneous technique using Kirschner’s wires secured by a metal block. First, the block is screwed into the lateral humeral cortex. Using a guide device, 2 wires are then sent through the block at a 35° angle to the humeral shaft and a 25° angle to each other. Once the fracture is manipulated into a reduced position, the wires are fixed into the head fragment and then locked into the metal block. Additional fragments can be secured with screws. Results in elderly patients are good, with Constant scores around 80% to 90% of the contralateral arm; however, the device is bulky and needs to be removed with a second operation.36,37

**Intramedullary nailing.** Intramedullary nails can be used in surgical neck fractures, but the starting point is often compromised in 3-part fractures. The nail starting point is slightly medial to the greater tuberosity and cuff tendon insertions. It’s preferable to go through the supraspinatus muscle belly at the lateral edge of the articular surface instead of splitting the tendon.38 Intramedullary nails have demonstrated acceptable results with Constant-Murley scores ranging from 60 to 85.39-43 Straight nails are preferred over curved nails because they are less likely to violate the rotator cuff44 and have a lower reoperation rate with better functional outcomes.39-41

**Locking plates.** Locking plates are commonly used for surgical neck fractures, but they tend to be associated with high rates of reoperation ranging from 16% to 30%. This is primarily due to screw cutout.45,46 Biomechanical studies suggest plates have inferior failure rates compared to nails in both 2-part47 and 3-part fractures.48 Plate weakness is primarily on the medial side, and therefore, special attention should be paid to varus angulation and medial comminution. These factors are associated with reduction loss. Bone void fillers, divergent screws, and medial calcar support (Figure 6) may prevent some of the complications associated with using plates in osteoporotic bone.22,49

**Two-Part Tuberosity Fractures**

Isolated greater tuberosity fractures account for 12% to 17% of proximal humerus fractures.28,50 Minimally displaced, isolated fractures of the greater tuberosity respond well to nonoperative management, but full recovery can take up to a year.51,52 Displaced fractures, particularly those with posterosuperior displacement, may benefit from fixation.53 Reduction techniques include screws or wires perpendicular to the fracture plane or suturing the fragment through bone tunnels (Figure 7). If the fragment is small or comminuted, suturing is recommended.

Fractures of the lesser tuberosity rarely occur in isolation. They more commonly occur in association with a posterior dislocation (0.2% of fractures) or a surgical neck fracture (0.3% of fractures).29,50 When associated with a posterior dislocation, they can be closed reduced with immobilization in slight external rotation. Large, displaced fragments or fragments involving the articular surface warrant fixation (Figure 8).11 Screws can be used for fixation if the fragment is large. For smaller fragments, fixation with sutures is recommended.

**Three- and Four-Part Fractures**

Three- and four-part fractures account for 21% to 23% of proximal humerus fractures.29,50 Closed reduction with nonoperative management is an option; however, the functional results tend to be poor with Constant scores ranging from 47 to 62.
operative treatment in 2-, 3-, or 4-part fractures. Although cur-

sive difference in outcomes between operative and non-

Evaluation by Randomisation (PROFHER) trial has not found a

no difference in outcome,55 and several studies have shown no

nonoperative treatment in 3- and 4-part fractures have shown

with complex fracture patterns. Some trials comparing plates to

Locking plates. Open reduction with plates can be considered in

patients with good bone quality, but this may not be possible

with complex fracture patterns. Some trials comparing plates to

nonoperative treatment in 3- and 4-part fractures have shown

no difference in outcome,55 and several studies have shown no

difference between locking plates and hemiarthroplasty (HA).56,57

When plating complex fractures, suture fixation of the tuberosi-
ties and medial augmentation with cement, bone graft, and calcar
screws is suggested (Figure 6). Fractures with valgus impaction
have better outcomes than patients with varus impaction in both
3- and 4-part fractures,58-60 so attention to medial support is
important. A randomized study comparing complex fractures treated
with and without a medial support screw showed superior Constant
scores (79 vs 70) and reduced failure rate (3.4% vs 23.1%) in the
group that had a medial support screw placed.61

Plate fixation is thought to have a higher risk of avascular
necrosis secondary to periosteal stripping. This may be obviated
by newer minimally invasive designs, which have achieved
Constant-Murley scores of 63 to 75.59,62 Several other plating
advancements have been made with relatively lower complica-
tions than historically reported. A recent 1-year follow-up
study of 54 patients treated with the S3 angular stable plate
reported a mean Constant score of 75 with only 5 complications
and no need for revision procedures.63 A 2-year follow-up
study using the radiolucent carbon fiber-reinforced polyether-
etherketone plate reported a mean constant score of 71.3.64

The use of a fibular graft strut to augment locking plate
constructs has shown promising results in patients with osteo-

Arthroplasty. Hemiarthroplasty or RTSA is frequently used in

situations of severe comminution, concern for humeral head
ischemia, and poor bone quality. The prosthesis can be augmen-
ted with autograft prepared from excised bone. After placement
of graft material, the greater and lesser tuberosity are sutured
first around the implant and second to the humeral cortex (Figure
9). This is typically done with horizontal cerclage sutures placed
through tunnels in the greater and lesser tuberosity. The horizon-
tal sutures are wrapped around the prosthetic stem and tightened.
Next, vertical sutures attach the tuberosities through bone tun-
nels in the anterolateral humeral cortex.68

Hemiarthroplasty. Hemiarthroplasty was historically the treat-
ment of choice for complex fractures, but results are mixed
and dependent on tuberosity healing. Recent HA studies have
failed to show benefits over nonoperative treatment.59,70 A
systematic review of 808 patients revealed a mean Constant
score of 57 with significant functional limitations (106° eleva-
tion and 92° abduction) but few reports of pain.71 The tech-
nique is technically challenging and requires a functional
rotator cuff with good reduction of the tuberosities. Excessive
lengthening and retroversion are associated with poor out-
comes, so attention to humeral lengthening and head retrover-
sion are important. Boileau et al suggest the worst combina-
tion is an excessively proud, retroverted prosthesis with a greater
tuberosity attached too inferiorly.72

Reverse total shoulder arthroplasty. Results from RTSA are pro-
mising. A 2013 systematic review concluded RTSA outcomes
are superior to HA outcomes,73 whereas an early 2014 systema-
tic review found improved forward flexion in RTSA but
decreased external rotation.74 More recent nonrandomized75,76
and randomized77 trials have demonstrated superiority of the
reverse prosthesis, with Constant scores 12 to 14 points higher
than HA. Reverse arthroplasty can be valuable as both a primary
procedure and as a secondary procedure for failed open reduc-
tions. Outcomes from primary procedures have been superior to

Figure 8. Axillary shoulder X-ray demonstrating a displaced fracture
of the lesser tuberosity. This fragment is amenable to suture fixation.

Despite low functional scores, pain is uncommon and some
patients are satisfied with the outcome of nonoperative

treatment.19,54 At 5 years, the Proximal Fracture of the Humerus:
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revised cases.\textsuperscript{78} Constant scores range from 44 to 67 with forward elevation between 97\degree and 138\degree.\textsuperscript{79-84} A recent 2016 study by Grubhofer et al included 51 patients with 3 years of follow-up who demonstrated Constant scores at 86\% of the contralateral shoulder.\textsuperscript{85} Postoperative scapular notching and component loosening remain an issue with unknown clinical significance,\textsuperscript{79,82,86} but there is evidence to suggest it is associated with base plate loosening and poor outcomes. Notching can be prevented by proper placement of the glenoid component.\textsuperscript{87,88}

**Conclusion**

Proximal humerus fractures in the elderly are common. A majority of minimally displaced fractures can be treated conservatively with early physical therapy. Treatment for displaced fractures should consider the patient’s level of independence, bone quality, and surgical risk factors. Fixation with percutaneous techniques, intramedullary nails, locking plates, and arthroplasty are all acceptable treatment options. With internal fixation, special attention should be paid to medial comminution, varus angulation, and restoration of the calcar. With arthroplasty, attention should be paid to anatomic restoration of the tuberosities and proper placement of the prosthesis. There is no clear evidence-based treatment of choice, and the surgeon should consider their comfort level with various procedures during the decision-making process.

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