Proximal Humerus Fracture
Fix, Replace, or Let Heal

Ian R. Penvose, MD[a], E. Scott Paxton, MD[b,*]

KEYWORDS

• Proximal • Humerus • Fracture • Open reduction and internal fixation
• Reverse total shoulder arthroplasty • Hemiarthroplasty

KEY POINTS

- Proximal humerus fractures are common upper extremity injuries that occur in a bimodal distribution and will only continue to increase with the aging population.
- While most proximal humerus fractures are treated nonoperatively, there are surgical options for these injuries, ranging from fixation to replacement.
- Patient factors, fracture type, and appropriate imaging will help guide treatment choices.
- If fixation is performed, the goal should be anatomic reduction, if this is not possible, arthroplasty should be considered.

INTRODUCTION

Overview

Proximal humerus fractures (PHF) are common upper extremity injuries that occur in a bimodal distribution and their incidence will increase with the aging population. Given the amount of motion the glenohumeral joint has, and the compensatory motion from the scapulothoracic joint, many PHFs can be treated nonoperatively. However, specific patient factors and fracture characteristics may drive surgeons to perform operative management. This article serves to highlight the best evidence to guide management to restore function after PHF.

Epidemiology

Fractures occurring in the upper extremity are common with an annual incidence of ~70 fractures per 10,000 persons with PHF occurring at a rate of 6 per 10,000 persons.[1] This number has increased significantly from 2008 (2.7 per 10,000 persons) and will likely continue to increase given the aging population and significant rise in the incidence in patients older than 70 years.[2,3] In fact, these fractures are predicted to increase by 50% in the near future secondary to the aging population.[4,5] Overall, PHF account for 4% to 6% of all fractures and occur in a standard bimodal distribution of younger patient populations with high energy mechanisms and older patient populations with low energy mechanisms.[4] PHFs are the third most common fracture occurring in individuals over the age of 65.[4,5] The majority of PHFs are seen in elderly individuals caused by low energy trauma classified as osteoporotic fragility fractures, which occur in a 3:1 female:male ratio.[6,7] Osteoporotic fragility fractures tend to be highly comminuted with poor bone quality, which further complicates treatment options and surgical management. Additional reported risk factors for PHFs include medical comorbidities including diabetes mellitus and epilepsy.[6–8]

Anatomy

The anatomy of the proximal humerus is important in understanding fracture patterns, healing potential and best treatment options. The proximal humerus can be separated into 4 parts: the greater tuberosity (GT), the lesser tuberosity (LT), the humeral head, and the humeral shaft. The humeral head and humeral shaft are anatomically distinct at the level of the surgical neck. The shoulder joint has the greatest

[a] Department of Orthopedics, Brown University William Alpert School of Medicine, RI, USA; [b] Department of Orthopedic Surgery, Brown University William Alpert School of Medicine; University Orthopedics, Inc., USA
* Corresponding author. Brown University William Alpert School of Medicine; Department of Orthopedics, 222 Richmond Street, Providence, RI 02903.
E-mail address: espaxton@uoi.com

Orthop Clin N Am 57 (2026) 67–77
https://doi.org/10.1016/j.ocl.2025.03.002

Abbreviations	
AP	anteroposterior
ASES	American Shoulder and Elbow Surgeons
CT	computed tomography
GT	greater tuberosity
HA	hemiarthroplasty
HST	head-shaft translation
IMN	intramedullary nail
LT	lesser tuberosity
ORIF	open reduction and internal fixation
PHF	proximal humerus fractures
PROFHER	Proximal Fracture of the Humerus Evaluation by Randomization
RCA	rotator cuff arthropathy
rTSA	reverse total shoulder arthroplasty

potential for range of motion in the body secondary to the shallow glenoid fossa in relation to the size of the humeral head. The stability of the shoulder is heavily reliant on the surrounding soft tissue structures such as ligaments, capsule, and muscle, which also play important role in fracture patterns and displacement. The subscapularis inserts onto the LT anteriorly while the supraspinatus, infraspinatus and teres minor insert onto the GT posterior and superior. Important anatomic characteristics include an approximate humeral neck-shaft angle of 135°, humeral retroversion ranging from 10 to 55° with an average retroversion of approximately 30°.[9–11] The humeral head has unique morphologic characteristics with the articular surface noted to be spherical in the center, which changes to a more elliptical shape along the peripheral edges. It also has a larger radius of curvature in the superior to inferior plane compared to the anterior to posterior plane. Anatomic position of the GT is approximately 6 mm to 8 mm inferior to the superior aspect of the humeral head articular cartilage.[9]

As mentioned, the surrounding soft tissue structures and their deforming forces play a significant role in fracture displacement. In 2-part surgical neck fractures, the pectoralis major internally rotates the humeral shaft while pulling the segment anteromedial. Concurrently, the rotator cuff abducts the proximal segment leading to varus malalignment and apex anterior deformity. If there is significant comminution, larger anteromedial fragments can be pulled posteromedial because of the latissimus dorsi and the teres major. In 3-part fractures, the supraspinatus, infraspinatus and teres minor displace the GT superomedially, and the unopposed forces of the subscapularis internally rotate the head.[12]

Fracture displacement may also lead to injury to the blood supply of the proximal humerus and humeral head, which may increase the risk of osteonecrosis and/or nonunion. Thus, it is an important consideration when discussing treatment options. The proximal humerus receives its blood supply from two branches of the axillary artery: the anterior and posterior humeral circumflex arteries with the latter supplying approximately 60% of the blood to the humeral head. Anatomically, the posterior humeral circumflex artery travels with the axillary nerve, which then passes through the quadrilateral space and then supplies the humeral head through a plexus of arterial branches. The anterior humeral circumflex artery's terminal anterolateral branch, known as the arcuate artery, ascends adjacent to the bicipital groove to the humeral head.[13–16] Specific fracture patterns such as disruption of the calcar increase the risk of humeral head avascularity and, therefore, require thoughtful consideration for treatment.

TREATMENT CLASSIFICATIONS

Imaging

Appropriate imaging is imperative to fully assess and understand the fracture pattern. Initial imaging studies typically consist of anteroposterior (AP), true AP (Grashey), scapular Y, and axillary view x-ray radiographs. If the patient is unable to tolerate an axillary view, a Velpeau view may be acquired. If the fracture is deemed stable, additional x-ray views may include internal and external rotation. Internal rotation may help visualize the lesser tuberosity by bringing it into plane, whereas external rotation brings into plane the greater tuberosity. However, in unstable fracture patterns, rotating the arm may not rotate the proximal fragment and patients rarely tolerate considerable external rotation in the setting of an acute fracture. If needing to further evaluate the glenoid rim or a hill-sacs lesion, in the setting of a fracture/dislocation, a West Point axillary view and a Stryker notch view may be helpful, respectively. It is imperative to get an AP view of the proximal humerus that profiles the humeral head/shaft relationship, otherwise varus displacement may be not be appreciated.[12]

In addition to assessing the fracture pattern, attention should also focus on bone quality and concern for bony lesions that may indicate a

pathologic fracture. Further evaluation for evidence of glenohumeral arthritis as well as signs of rotator cuff incompetence (acromial spurring, GT rounding) should be noted as it may alter treatment options. Evaluation of the bone quality can also be estimate on a plain radiograph using the deltoid tuberosity index.[17]

Advanced, cross-sectional imaging in the form of a computed tomography (CT) scan may be helpful to better characterize the fracture pattern adequately and/or for preoperative planning. It may also help identify additional injuries such as glenoid fractures. Three-dimensional reconstruction of the fracture can also be obtained with CT imaging to help preoperative plan. Fatty infiltration of rotator cuff musculature can be assessed on CT scan especially when considering arthroplasty. Indications for MRI are limited and are often not performed.

Classification Systems

The Neer classification, introduced by Charles Neer in 1970, remains the most commonly used system today and categorizes fractures based on the number of displaced parts. The classification system involves 4 parts: the humeral head, the greater tuberosity, the lesser tuberosity, and the humeral shaft. Fracture fragments are deemed *parts* if they are displaced by greater than 1 cm or angulated greater than 45°, although, it is generally acknowledged that these values are arbitrary.

One of the main considerations for surgical intervention relates to the possibility of avascular necrosis, which is one of the most common complications of both operative and nonoperative treatment of PHF. The predictive criteria for humeral head ischemia was described in 2004 by Hertel and colleagues.[18] The authors found that if there was less than 8 mm of calcar length attached to the articular segment, if there was a disrupted medial hinge (not valgus impacted), or with increasing fracture comminution there was decreased probability that the vascular supply to the articular head was intact. Interestingly, initial humeral head avascularity did not correlate with findings of later avascular necrosis in these patients followed up at an average of 5 years postoperatively.[19] Despite these later findings, these characteristics are widely described as predictors of avascular necrosis.[19]

There are additional classification systems such as the AO proximal humerus classification, but it is important to note that interobserver reliability for both systems are low. The AO classification is rarely used in practice and generally only encountered in research studies.

Unfortunately, no classification system has shown good agreement amongst evaluators. Most surgeons utilize a modified version of the Neer system referring to fractures as 2- part, 3-part or 4-part, but rarely is the strict definition of a part by 1 cm of displacement or 45° of angulation used. Additionally, no fracture classification system has been found to successfully guide treatment or predict outcomes.

Indications

There are a multitude of factors to consider when counseling patients on indications for operative treatment regarding PHF including age, medical comorbidities, level of function, bone quality, and fracture characteristics. Unfortunately, there have not been any agreed upon indications for operative versus nonoperative treatment of PHF. Ultimately, a majority of PHF are mildly displaced and/or are in individuals who are low demand, older, or have significant comorbidities.[20–22] Therefore, nonoperative treatment for PHF is common with up to 85% being managed without surgery.[23,24]

Nonoperative management is comprised of sling immobilization for fracture protection. Patients are encouraged to initiate active elbow, wrist, and finger exercises to prevent stiffness and resolve swelling. While fracture pattern and serial radiographic evaluation will ultimately help decide when sling immobilization should be discontinued, most patients are able to wean out of the sling within 6 weeks of injury. Regardless of fracture pattern, studies have shown that delay in motion beyond 2 weeks has a detrimental effect on patient reported outcomes and shoulder range of motion.[25–28] Koval and colleagues showed improvement in range of motion when one-part fractures initiate physical therapy within 2 weeks.[27,28] This understanding, however, must be balanced with the possibility that early motion may worsen displacement and increase the risk of malunion or even nonunion. Although risk of nonunion in these fractures is generally low, especially for 3-and 4-part fractures.[29–31] The nonoperative treatment plan is to be tailored for each individual patient dependent on their initial fracture pattern, healing potential, medical comorbidities, and is evaluated at follow-up appointments with the treating orthopedist. Fractures with excessive comminution, increasing displacement, or those without evidence of healing may need to be addressed surgically, but patient factors need to be taken into consideration.

There have been recent studies that have evaluated nonoperative versus operative management

of PHFs. The Proximal Fracture of the Humerus Evaluation by Randomization (PROFHER) study compared open reduction and internal fixation (ORIF) to nonoperative treatment and demonstrated equal outcomes and no improvement with operative treatment when compared to nonoperative treatment at 2 years.[32,33] However, it is important to note that this study did not use strict inclusion criteria and did not assess for the quality of the reduction or fixation. In particular, the PROFHER study included a large percentage of 1-part and 2-part fractures with varying levels of surgeon experience in the operative group. Additionally, only 45% (n=563) of the screened patients were deemed eligible and only 44% (n=250) of eligible patients agreed to participate in the study. Further, patients were excluded if there were *clear indications for surgical intervention* such as *soft-tissue compromise*, but this was not more formally defined.[32,33]

Other randomized controlled trials have shown similar results when comparing operative intervention to nonoperative treatment. Boons and colleagues evaluated nonoperative management compared to hemiarthroplasty (HA) in 4-part fractures with no meaningful difference in outcomes or strength testing at 12 months, although there was an 8% rate of osteonecrosis and 16% rate of malunion in the nonoperative group.[34] Fjalestad and Hole also randomized patients to either nonoperative treatment or ORIF and found that at 2 years of follow-up, no significant differences were found between the 2 groups.[35]

Additionally, Beks and colleagues performed a meta-analysis identifying 22 studies where 7 were randomized trials.[36] Overall, there were 1743 patients with 910 being treated operatively and 833 treated nonoperatively. While operatively treated fractures were less likely to go on to nonunion, the difference was not significant, and there was no difference in the rate of avascular necrosis between the two groups. Nonoperative management led to decreased need for reintervention (or initiation of intervention) in the future. Functional outcomes were compared with Constant-Murley scores and demonstrated no significant difference between the groups. It is important to note that in this meta-analysis, 80% of patients treated operatively were managed with ORIF, with the remaining patients treated with HA; reverse total shoulder arthroplasty (rTSA); intramedullary nails; and a combination of K-wires, screws, and tension-band constructs. There was no subgroup analysis to differentiate outcomes between operative intervention-type.[36]

Conversely, some studies have identified advantages of operative management over nonoperative treatment. For example, Olerud and colleagues performed 2 studies assessing treatment options for PHF.[37,38] The initial study randomized patients with 3-part PHF to either nonoperative management or internal fixation with a locking plate construct.[37] Patients fixed operatively with locking plates did demonstrate increased range of motion and outcomes.[37] A follow-up study included patients with 4-part PHF that were randomized to either nonoperative treatment or HA.[38] Patients who underwent HA demonstrated decreased pain without any appreciable range of motion differences.[38] A recent matched cohort analysis by Haws and colleagues also found increased ROM, decreased pain, and improved functional outcomes when comparing patients who underwent rTSA to nonoperative management.[39] These studies do highlight the benefit of operative management in certain situations.

Predictive Models

A few authors have endeavored to create a predictive model to assist surgeons in making treatment decisions. In a study by Goudie and colleagues, the authors looked at predictive factors that may lead to nonunion after nonoperative treatment of PHF at their institution.[29] Overall, 10.4% of patients (n=231) went on to develop nonunion. They found that patients with a decreased head-shaft angle (HAS) ($<90°$), increased head-shaft translation (HST) ($>50\%$) and smoking were all predictors of higher rates of nonunion. Through their work they developed a model, PHF assessment of risk of nonunion, which was externally validated and may be used to predict outcomes in nonoperative management. Thus, patients who are smokers, have decreased HAS, or increased HST may benefit from operative intervention to minimize nonunion risk. Smoking also increases complication rates, and should be taken into consideration when electing for surgical intervention.[29]

Song and colleagues also evaluated radiographic parameters as predictors of functional recovery of nonoperative treatment.[40] They found that initial radiographic deformity alone had a limited ability to predict short-term functional recovery in treating patients nonoperatively. However, they did find that initial retroversion was the most important predictor for functional recovery and fractures with a higher initial valgus and retroversion tend to displace more and may warrant closer follow-up and early transition to surgical management.[40]

Despite these efforts, it is still very difficult to predict which patients with will have success with nonoperative treatment especially because for many patients, especially older patients, their satisfaction with the outcome is not always correlated with range of motion of the shoulder.

SURGICAL MANAGEMENT

Treatment Decisions for Specific Fracture Patterns

Two-part fractures

Two-part fractures generally consist of a fracture line through the surgical neck creating two parts consisting of the articular surface with the tuberosities and the humeral shaft. Surgical neck fractures account for approximately two-thirds of all PHFs. It is crucial to understand the fracture pattern, along with the patient's medical history, physiologic age, and functional ability, to guide management. Typically, surgical neck fractures occur in a standard bimodal distribution of younger patient populations with high energy mechanisms and older patient populations with low energy mechanisms.[4] Younger, high energy mechanism injuries are more likely to be significantly displaced or angulated fractures and are often managed surgically with open reduction internal fixation. Indications for surgical management are patient dependent, but typically involve fracture patterns with greater than 50% displacement and greater than 45° of angulation.[41] Valgus displacement is usually tolerated better than varus displacement. Additionally, these fractures often go into an apex anterior deformity, which can limit forward flexion. In younger, more active patients less deformity is usually accepted. Fixation options include percutaneous techniques, locked plating or intramedullary nail (IMN) fixation. In select cases, there may be a role for arthroplasty, however, arthroplasty is typically reserved for 3- or 4-part fracture patterns. In the elderly patient, bony contact and healing of fracture segments may be all that is necessary for a functional result with the majority being treated nonoperatively. If displaced, the typical pattern of displacement in surgical neck fractures is varus angulation. Varus deformity is a challenging fracture pattern that has an increased risk of malunion, hardware failure, screw cutout, and ultimately, inferior outcomes when treated with ORIF.[42–45] When treated nonoperatively, patients with varus angulation tend to fall into further varus over the first 4 to 8 weeks with concurrent loss of forward elevation and abduction motion but with maintained rotation.[46,47] It is imperative to identify varus deformity to counsel patients, guide treatment decision making, and ensure that if surgical management is pursued, the correct alignment through the medial calcar is restored.[48–50]

Three-part fractures

In 3-part fractures, the fracture plane typically occurs through the surgical neck and between the greater and lesser tuberosity/head fragment, usually just posterior to the bicipital groove. The GT displaces in the aforementioned superior, posterior, medial position from the dynamic pull of the attached rotator cuff.[50,51] The humeral head is then retroverted due to the dynamic pull of the subscapularis on the intact lesser tuberosity. The opposite is true if the fracture involves the LT, although this is very rare. Surgical treatment options are similar to 2-part fractures, including closed reduction percutaneous pinning (CRPP), ORIF, IMN fixation, HA, or rTSA.[52] Arthroplasty is typically reserved for comminuted osteoporotic fractures in older patients, and rTSA has been shown to have better outcomes than HA.[53] Younger patients with severe articular damage may still be candidates for HA, but HA has become much less popular with the introduction of the rTSA.

Four-part fractures

Four-part PHF involve all parts including both the greater and lesser tuberosities. These often require surgical management and nonoperative treatment increases the risk of dysfunction, malunion, nonunion, and/or arthritis. Nonoperative management is generally reserved for less displaced fractures or medically comorbid or elderly patients. Again, surgical management options include CRPP, ORIF, IMN, HA, or rTSA.[33,52,54–58] There are some, albeit few, indications for intramedullary nail fixation. Although third generation nails are making it a more viable option in the appropriate setting.[59] If the fracture is characterized as a valgus-impacted 4-part fracture, it is important to understand the prognostic benefits as the medial blood supply through the calcar is more likely to be preserved.[60–64] The fracture pattern is identified by impaction of the lateral aspect of the humeral articular surface, which in turn leads to compression. This leads to decreased rates of osteonecrosis compared to more traditional 4-part PHF as noted above, approximately 5% to 10% as opposed to 20% to 30%.[63–66] These valgus-impacted 4-part fractures are more amenable to nonoperative management, but

are also more amenable to ORIF when surgical intervention is pursued.

OPERATIVE DECISION MAKING

In contemplating the course of treatment for a fracture, the initial decision revolves around whether to pursue an operative or nonoperative approach. Consider the less active, older, or more medically compromised individual, whose limited social support and coping mechanisms might render them surprisingly tolerant of nonoperative management. Conversely, those who are more active, biologically younger, and possess greater resilience may find the scales of risk and reward tipping toward surgical intervention. Yet, irrespective of the chosen path, the patient's participation in their rehabilitation protocol plays a critical factor. Even with precise anatomic reduction through operative intervention, the absence of diligent rehabilitation may render the surgical effort no more beneficial than nonoperative care, especially given the shoulder's tendency to stiffen. Thus, those who pursue anatomic alignment and are willing to commit to postoperative recovery are prime candidates for surgical intervention. However, quantifying these variables is a challenging task, making the development of standard surgical indications very difficult.

The Neer Circle of the American Shoulder and Elbow Society performed a study which attempted to gain consensus among 86 identified experts in the shoulder and elbow field using the Delphi process.[67] The goal of the study was to understand preferences on general treatment approaches regarding management of PHF. Consensus was reached that important factors guiding management include age, functional demand, fracture pattern, bone quality, and the presence of more significant medical comorbidities.[67] Experts agreed that medial calcar involvement, gender, and arm dominance would have a low impact. In young, healthy patients, consensus was reached to pursue operative management in displaced 2-part shaft fracture (98%), displaced 3-part varus fracture (98%), displaced 3-part valgus fracture (98%), displaced 4-part fracture (100%), 4-part fracture dislocation (98%), and 4-part valgus impacted fractures (95%). For older unhealthy patients, consensus for operative management was only reached in 4- part fracture dislocations (100%).[67] This study demonstrated that consensus when managing PHF is limited to specific scenarios. There was no consensus on preferred rehab protocols, regardless of management choice.[67] In reality, most patients fall into the gray areas between the extremes of young, healthy individuals and older, less healthy ones, as these are subjective classifications.

Lapner and colleagues recently published guidelines in the *Canadian Journal of Surgery*, based on current literature, indicating that while ORIF improves patient-reported outcomes and pain measures, results are comparable to nonoperative treatment.[68] However, patients undergoing ORIF for 3-part or 4-part fractures are more likely to require reoperation compared to those initially managed nonoperatively.[35,37] In fact, despite 86% of patients having a *good primary reduction* after ORIF, 30% of patients required reoperation including 13% of patients having a fracture complication requiring major.[37]

Hao and colleagues polled orthopedic shoulder and elbow surgeons and trauma surgeons regarding indications for surgical treatment for PHF. They found the decision to proceed with HA or rTSA as opposed to ORIF was largely related to age, bone quality, rotator cuff dysfunction, and the involvement of the articular surface.[69] 90% of shoulder and elbow trained surgeons would select arthroplasty in patients over the age of 50 years with head split fracture patterns.[69]

Currently, ORIF with a proximal humerus locking plate is considered the preferred method for fixing displaced fractures. Robinson and colleagues reported a 90% survivorship of ORIF at 10 years, with patients experiencing good to excellent levels of pain relief, function, and satisfaction.[45] This represents some of the most compelling evidence in favor of this procedure, endorsing the use of primary ORIF in medically fit patients with displaced PHF. For younger, healthy patients with such fracture patterns, ORIF typically results in union and favorable pain, functional, and patient-reported outcomes, albeit with a nonzero risk of complications or reoperation.[35,37,68]

While ORIF has long been considered the gold standard for certain fracture types, emerging evidence suggests that IMN is gaining traction and shows significant promise as an alternative approach. Outcomes for 2-part fractures are comparable in terms of functional patient-reported outcomes, pain, and reoperation rates. Intramedullary nail fixation may even be appropriate for 3-part and 4-part fractures as well.[70–72] The third-generation IMN is a viable treatment option for PHF, particularly those with metadiaphyseal extension in 2-part and 3-part fractures. Advances in nail design, surgical technique, and surgeon experience have expanded the indications and frequency

of nailing. Recent data indicate high union rates, favorable patient-reported outcomes, and low complication rates, which are noninferior to plate fixation. Current literature supports the evolution of IMN fixation as a significant consideration for PHF management.[59]

While many patient factors must be considered in the treatment of a PHF, the surgeon must also assess their own skill level. The surgical technique, specifically the quality of reduction, is crucial to achieve a successful outcome after an ORIF. A study by Schnetzke and colleagues involving 98 patients undergoing plating of PHF revealed that only 40% achieved anatomic or acceptable reduction.[73] Poorer quality of reduction was associated with higher complication rates and worse outcomes, with complications such as screw cut-out and increased reoperation rates being linked to malreduction.[74] In cases where an anatomic reduction is unattainable, arthroplasty may present a more suitable alternative. The surgeon must be able to achieve and maintain an anatomic reduction when performing an ORIF of a PHF.

When arthroplasty was first introduced in the treatment of PHF by Charles Neer in the 1970s, it was in the form of HA. It was not until 2003, when the rTSA was approved in the United States, that American surgeons were able to utilize reverse shoulder replacement to treat PHFs. Since that time, rTSA has become much more common than HA. rTSA has demonstrated higher functional outcomes and lower pain scores while showing a decreased incidence of reoperation when compared to HA.[75–79]

Yahuaca and colleagues, compared older patients with higher ASA scores treated with arthroplasty to younger patients with lower ASA scores treated with ORIF. Both groups exhibited improvements in motion and function at 1 year.[80] However, ORIF and HA demonstrated significantly more reoperations when compared to patients who underwent rTSA secondary to progression of osteoarthritis, screw-cut out or nonunion. When controlled for all variables including age and medical comorbidities, rTSA or HA have been shown to have superior Constant-Murley scores with similar outcomes in pain scores at 24 months compared to ORIF.[55,81]

Timing of arthroplasty has also been a source of debate, as there has been interest in a *delayed reverse strategy* to give the patient a chance at nonoperative treatment with a later rTSA if needed or an attempt at ORIF with arthroplasty as a salvage option. However, some evidence suggests that acute intervention is preferable to delayed surgery following nonoperative management or open reduction internal fixation (ORIF). A study by Lu and colleagues demonstrated that patients undergoing acute rTSA for PHF exhibited significantly improved range of motion in forward flexion, external rotation, and abduction compared to those receiving delayed rTSA after nonoperative management.[82] Furthermore, the acute rTSA group achieved higher American Shoulder and Elbow Surgeons (ASES) and Constant-Murley scores. Subgroup analysis further revealed superior ASES scores in the acute rTSA cohort relative to those undergoing rTSA post-ORIF.[82] Additionally, the acute rTSA group experienced a reduction in overall complications compared to delayed rTSA following conservative management or ORIF.[82] Conversely, research by Shannon and colleagues found no statistically significant differences in clinical outcomes between acute rTSA and rTSA following ORIF, with only a marginal increase in complication rates (8% vs 5%), suggesting the potential viability of ORIF with rTSA as a contingency.[83]

In the authors' experience, a successful ORIF with anatomic reduction and healing complicated by subsequent avascular necrosis may offer the advantage of reduced and healed tuberosities, potentially enhancing outcomes in later arthroplasty. In such cases, late HA (or even anatomic total shoulder arthroplasty) may be considered if the tuberosities have healed anatomically. This is especially true in the younger patient. Unfortunately, there is no published data to date on the results of rTSA or HA after ORIF in the setting of anatomically healed tuberosities. In younger patients, where avoiding arthroplasty is preferable, attempting an ORIF may be justified, even with risk of avascular necrosis, provided the tuberosities can be repaired anatomically.

If deciding to proceed with rTSA, it is important to understand the difference in outcomes of patients who undergo rTSA after fracture as compared to those who undergo rTSA for rotator cuff arthropathy to accurately counsel the patient of realistic expectations. Unfortunately, there are certain PHFs that no matter what treatment is employed, the shoulder does not return to the preinjury state. A study by Maier and colleagues looked at outcomes after rTSA in 189 patients. They included 119 with rotator cuff arthropathy (RCA) compared to 70 with a PHF. The authors found that patients reported similar levels of pain; however, patients with PHF reported greater perceived disability compared to the RCA cohort with significantly lower outcomes in ASES, SPADI-Disability, and

SPADI-Total scores.[84] This data shows that the indication for rTSA has a substantial impact on outcome.

The operative management of PHF requires a nuanced approach, balancing patient-specific factors such as age, activity level, and medical comorbidities. Patient expectations and motivation must also be considered. Although ORIF is still favored for many displaced fractures, especially in younger and healthier individuals, the use of IMN fixation is on the rise. Additionally, in older patients rTSA is generally the operative treatment of choice. The choice between these interventions is influenced by the quality of reduction achievable, with arthroplasty often favored when anatomic reduction is not possible.

SUMMARY

PHF are prevalent injuries, particularly among the aging population, and their management requires a tailored approach considering patient-specific factors such as age, activity level, and comorbidities. While nonoperative treatment is common, surgical options, including fixation or replacement, are often utilized based on fracture complexity and patient needs. When performing fixation of these fractures, anatomic reduction must be able to be obtained and maintained, otherwise arthroplasty should be considered. Ultimately, the choice of treatment should align with the patient's functional goals and lifestyle, ensuring optimal recovery and satisfaction. As research progresses, these insights will continue to refine surgical indications and enhance patient outcomes.

CLINICS CARE POINTS

- Proximal humerus fractures (PHF) account for 4% to 6% of all fractures.
- Nonoperative treatment for PHF is common, 85% being managed without surgery.
- There is a decreased need for reintervention in the future with nonoperative intervention.
- Some studies note no significant difference in functional outcomes between the nonoperative and operative interventions.
- Other studies note decreased pain, increased range of motion, and improved functional outcomes after operative intervention.
- Open reduction internal fixation is a viable option especially in younger, healthy patients with high survivability; intramedullary nailing is also gaining popularity.
- Arthroplasty, especially reverse total shoulder arthroplasty, over hemiarthroplasy, has improved outcomes compared to ORIF in the right patient and fracture.
- Difficult indications need thorough discussion based on fracture complexity and patient needs.

DISCLOSURE

E. Scott Paxton, MD is a consultant for Miami Device Solutions, Stryker and Catalyst Orthoscience. He receives royalties from Stryker and Catalyst Orthoscience. Ian R. Penvose has no disclosures. During the preparation of this work the authors used Gen AI. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

REFERENCES

1. Karl JW, Olson PR, Rosenwasser MP. The epidemiology of upper extremity fractures in the United States, 2009. J Orthop Trauma 2015;29:e242–4.
2. McLean AS, Price N, Graves S, et al. Nationwide trends in management of proximal humeral fractures: an analysis of 77,966 cases from 2008 to 2017. J Shoulder Elbow Surg 2019;28:2072–8.
3. Klug A, Gramlich Y, Wincheringer D, et al. Trends in surgical management of proximal humeral fractures in adults: a nationwide study of records in Germany from 2007 to 2016. Arch Orthop Trauma Surg 2019;139:1713–21.
4. Gupta AK, Harris JD, Erickson BJ, et al. Surgical management of complex proximal humerus fractures: a systematic review of 92 studies including 4500 patients. J Orthop Trauma 2015;29(1):54–9.
5. Kim SH, Szabo RM, Marder RA. Epidemiology of humerus fractures in the United States: nationwide emergency department sample, 2008. Arthritis Care Res 2012;64:407–14.
6. Nho SJ, Brophy RH, Barker JU, et al. Innovations in the management of displaced proximal humerus fractures. J Am Acad Orthop Surg 2007;15(1):12–26.
7. Calvo E, Morcillo D, Foruria AM, et al. Nondisplaced proximal humeral fractures: high incidence among outpatient-treated osteoporotic fractures and severe impact on upper ex- tremity function and patient subjective health perception. J Shoulder Elbow Surg 2011;20:795–801.
8. Triplet J., D.O., Proximal humerus fractures. Orthobullets, Available at: https://www.orthobullets.com/trauma/1015/proximal-humerus-fractures (Accessed 15 September 2024), 2025.
9. Iannotti JP, Gabriel JP, Schneck SL, et al. The normal glenohumeral relationships. An anatomical

study of one hundred and forty shoulders. J Bone Joint Surg Am 1992;74:491–500.
10. Pearl ML, Volk AG. Retroversion of the proximal humerus in relationship to prosthetic replacement arthroplasty. J Shoulder Elbow Surg 1995;4:286–9.
11. Thompson Jon. Netter's concise orthopaedic anatomy. 2nd Edition. Elsevier, ISBN 978-0-323-42970-2; 2016. Updated Edition.
12. DeFroda S, Paxton ES. Open reduction internal fixation of proximal humerus fractures. 3rd Edition. Wiesel shoulder and elbow; 2020. Chapter 16.
13. Green A. Proximal humerus fractures.Norris TROrthopaedic knowledge update: shoulder and elbow 2. IL: American Academy of Orthopaedic Surgeons-Rosemont; 2002. p. 209–17.
14. Gerber C, Schneeberger AG, Vinh TS. The arterial vascularization of the humeral head. An anatomical study. J Bone Joint Surg Am 1990;72:1486–94.
15. Laing PG. The arterial supply of the adult humerus. J Bone Joint Surg Am 1956;38-A:1105–16.
16. Hettrich CM, Boraiah S, Dyke JP, et al. Quantitative assessment of the vascularity of the proximal part of the humerus. J Bone Joint Surg AM 2010;92(4): 943–8.
17. Spross C, Kaestle N, Benninger E, et al. Deltoid tuberosity index: a simple radiographic tool to assess local bone quality in proximal humerus fractures. Clin Orthop Relat Res 2015;473(9):3038–45.
18. Hertel R, Hempfing A, Stiehler M, et al. Predictors of humeral head ischemia after intracapsular fracture of the proximal humerus. J Shoulder Elbow Surg 2004;13(4):427–33.
19. Bastian JD, Hertel R. Initial post-fracture humeral head ischemia does not predict development of necrosis. J Shoulder Elbow Surg 2008;17(1):2–8.
20. Einarsson F. Fracture of the upper end of the humerus: discussion based on the follow-up of 302 cases. Acta Orthop Scand Suppl 1958;32:1–215.
21. Lobo MJLW. Classification and closed treatment of proximal humerus fractures.Wirth MARockwood CAProximal Humerus Fractures. IL: American Academy of Orthopaedic SurgeonsRosemont; 2005.
22. Rasmussen S, Hvass I, Dalsgaard J, et al. Displaced proximal humeral fractures: results of conservative treatment. Injury 1992;23:41–3.
23. Laux CJ, Grubhofer F, Werner CML, et al. Current concepts in locking plate fixation of proximal humerus fractures. J Orthop Surg Res 2017;12:137.
24. Patel AH, Wilder JH, Ofa SA, et al. Trending a decade of proximal humerus fracture management in older adults. JSES Int 2022;6:137–43.
25. Hodgson S. Proximal humerus fracture rehabilitation. Clin Orthop Relat Res 2006;442:131–8.
26. Bertoft ES, Lundh I, Ringqvist I. Physiotherapy after fracture of the proximal end of the humerus. Comparison between two methods. Scand J Rehabil Med 1984;16:11–6.
27. Koval KJ, Gallagher MA, Marsicano JG, et al. Functional outcome after minimally displaced fractures of the proximal part of the humerus. J Bone Joint Surg Am 1997;79:203–7.
28. Koval KJ, Zuckerman JD. Orthopaedic challenges in the aging population: trauma treatment and related clinical issues. Instr Course Lect 1997;46: 423–30.
29. Goudie EB, Robinson CM. Prediction of nonunion after nonoperative treatment of a proximal humeral fracture. J Bone Joint Surg Am 2021;103(8):668–80.
30. Court-Brown CM, McQueen MM. Nonunions of the proximal humerus: their prevalence and functional outcome. J Trauma 2008;64(6):1517–21.
31. Cadet ER, Yin B, Schulz B, et al. Proximal humerus and humeral shaft nonunions. J Am Acad Orthop Surg 2013;21(9):538–47 [published correction appears in J Am Acad Orthop Surg. 2013 Nov; 21(11):21a].
32. Rangan A, Handoll H, Brealey S, et al. Surgical vs nonsurgical treatment of adults with displaced fractures of the proximal humerus: the PROFHER randomized clinical trial. JAMA 2015;313(10):1037–47.
33. Handoll H, Brealey S, Rangan A, et al. The ProFHER (PROximal Fracture of the Humerus: evaluation by Randomisation) trial - a pragmatic multicentre randomised controlled trial evaluating the clinical effectiveness and cost-effectiveness of surgical compared with non-surgical treatment for proximal fracture of the humerus in adults. Health Technol Assess 2015;19(24):1–280.
34. Boons HW, Goosen JH, van Grinsven S, et al. Hemiarthroplasty for humeral four-part fractures for patients 65 years and older: a randomized controlled trial. Clin Orthop Relat Res 2012;470(12):3483–91.
35. Fjalestad T, Hole MO, Hovden IA, et al. Surgical treatment with an angular stable plate for complex displaced proximal humeral fractures in elderly patients: a randomized controlled trial. J Orthop Trauma 2012;26:98–106.
36. Beks RB, Ochen Y, Frima H, et al. Operative versus nonoperative treatment of proximal humeral fractures: a systematic review, meta-analysis, and comparison of observational studies and randomized controlled trials. J Shoulder Elbow Surg 2018; 27(8):1526–34.
37. Olerud P, Ahrengart L, Ponzer S, et al. Internal fixation versus nonoperative treatment of displaced 3-part proximal humeral fractures in elderly patients: a randomized controlled trial. J Shoulder Elbow Surg 2011;20(5):747–55.
38. Olerud P, Ahrengart L, Ponzer S, et al. Hemiarthroplasty versus nonoperative treatment of displaced 4-part proximal humeral fractures in elderly

patients: a randomized controlled trial. J Shoulder Elbow Surg 2011;20(7):1025–33.
39. Haws BE, Andrew SS, Karnyski S, et al. Superior outcomes with reverse shoulder arthroplasty versus nonoperative management for proximal humerus fractures: a matched cohort analysis. J Orthop Trauma 2023;37(6):e247–52.
40. Song J, Joo LC, Jonathan LCC, et al. Evaluating the association of radiographic parameters of proximal humerus fractures managed conservatively with functional outcomes. Arch Orthop Trauma Surg 2024;144(8):3461–8.
41. Blaine TA, Levine WN. Fractures of the proximal humerus.Rockwood Jr CAMFr. WB SaundersPhiladelphia: Wirth MALippitt SBThe Shoudler; 2004. p. 355–412.
42. Capriccioso CE, Zuckerman JD, Egol KA. Initial varus displacement of proximal humerus fractures results in similar function but higher complication rates. Injury 2016;47:909–13.
43. Chandrappa MH, Hajibandeh S, Hajibandeh S. Postoperative outcomes of initial varus versus initial valgus proximal humerus fracture: a systematic review and meta-analysis. J Clin Orthop Trauma 2017;8:14–20.
44. Klug A, Wincheringer D, Harth J, et al. Complications after surgical treatment of proximal humerus fractures in the elderly-an analysis of complication patterns and risk factors for reverse shoulder arthroplasty and angular-stable plating. J Shoulder Elbow Surg 2019;28:1674–84.
45. Robinson CM, Stirling PHC, Goudie EB, et al. Complications and long-term outcomes of open reduction and plate fixation of proximal humeral fractures. J Bone Joint Surg Am 2019;101:2129–39.
46. Duparc F. Malunion of the proximal humerus. Orthop Traumatol Surg Res 2013;99(1 Suppl): S1–11.
47. Cheung EV, Sperling JW. Management of proximal humeral nonunions and malunions. Orthop Clin North Am 2008;39(4):475–vii.
48. Jung SW, Shim SB, Kim HM, et al. Factors that influence reduction loss in proximal humerus fracture surgery. J Orthop Trauma 2015;29:276–82.
49. Zhao L, Qi YM, Yang L, et al. Comparison of the effects of Proximal Humeral Internal Locking System (PHILOS) alone and PHILOS combined with fibular allograft in the treatment of neer three- or four-part proximal humerus fractures in the elderly. Orthop Surg 2019;11:1003–12.
50. Naranja RJ Jr, Iannotti JP. Displaced three- and four-part proximal humerus fractures: evaluation and management. J Am Acad Orthop Surg 2000; 8:373–82.
51. Iannotti JP, Ramsey ML, Williams GR Jr, et al. Nonprosthetic management of proximal humeral fractures. Instr Course Lect 2004;53:403–16.
52. Jobin CM, Galdi B, Anakwenze OA, et al. Reverse shoulder arthroplasty for the management of proximal humerus fractures. J Am Acad Orthop Surg 2015;23:190–201.
53. Han PF, Yang S, Wang YP, et al. Reverse shoulder arthroplasty vs. hemiarthroplasty for the treatment of osteoporotic proximal humeral fractures in elderly patients: a systematic review and meta-analysis update. Exp Ther Med 2022;24(4):637.
54. Mata-Fink A, Meinke M, Jones C, et al. Reverse shoulder arthroplasty for treatment of proximal humeral fractures in older adults: a systematic review. J Shoulder Elbow Surg 2013;22:1737–48.
55. Fraser AN, Bjordal J, Wagle TM, et al. Reverse shoulder arthroplasty is superior to plate fixation at 2 years for displaced proximal humeral fractures in the elderly: a multicenter randomized controlled trial. J Bone Joint Surg Am 2020;102:477–85.
56. Harrison AK, Gruson KI, Zmistowski B, et al. Intermediate outcomes following percutaneous fixation of proximal humeral fractures. J Bone Joint Surg Am 2012;94:1223–8.
57. Clavert P, Adam P, Bevort A, et al. Pitfalls and complications with locking plate for proximal humerus fracture. J Shoulder Elbow Surg 2010;19:489–94.
58. Ong CC, Kwon YW, Walsh M, et al. Outcomes of open reduction and internal fixation of proximal humerus fractures managed with locking plates. Am J Orthop 2012;41:407–12.
59. Paxton ES, Penvose IR: Intramedullary Nailing. Rockwood & Matsen's The Shoulder, 7e. 2025. Pending Final Print.
60. Jakob RP, Kristiansen T, Mayo K, et al. Classification and apsects of treatment of fractures of the proximal humerus.Bateman JEWelsh RPSurgery of the Shoulder. MosbySt. Louis 1984;330–43.
61. Brooks CH, Revell WJ, Heatley FW. Vascularity of the humeral head after proximal humeral fractures. An anatomical cadaver study. J Bone Joint Surg Br 1993;75:132–6.
62. Jakob RP, Miniaci A, Anson PS, et al. Four-part valgus impacted fractures of the proximal humerus. J Bone Joint Surg Br 1991;73:295–8.
63. Resch H, Beck E, Bayley I. Reconstruction of the valgus-impacted humeral head fracture. J Shoulder Elbow Surg 1995;4:73–80.
64. Resch H, Povacz P, Frohlich R, et al. Percutaneous fixation of three- and four-part fractures of the proximal humerus. J Bone Joint Surg Br 1997;79:295–300.
65. Robinson CM, Page RS. Severely impacted valgus proximal humeral fractures. Results of operative treatment. J Bone Joint Surg Am 2003;85:1647–55.
66. Resch H, Hubner C, Schwaiger R. Minimally invasive reduction and osteosynthesis of articular fractures of the humeral head. Injury 2001;32:SA25–32.
67. Williams AA, Dey Hazra RO, Dornan G, et al. Consensus statement on the treatment of proximal

humerus fractures: a Delphi approach by the neer Circle of the American shoulder and elbow surgeons. J Shoulder Elbow Surg 2025.
68. Lapner P, Sheth U, Nam D, et al. Position statement: management of proximal humerus fractures. Can J Surg 2024;67(2):E112–7.
69. Hao KA, Patch DA, Reed LA, et al. Factors influencing surgical management of proximal humerus fractures: do shoulder and trauma surgeons differ? J Shoulder Elbow Surg 2022;31(6):e259–69.
70. Helfen T, Siebenbürger G, Fleischhacker E, et al. Operative treatment of 2-part surgical neck type fractures of the proximal humerus in the elderly: cement augmented locking plate PHILOS^{TM} vs. proximal humerus nail multiloc®. Injury 2020;51:2245–52.
71. Zhu Y, Lu Y, Shen J. et alLocking intramedullary nails and locking plates in the treatment of two-part proximal humeral surgical neck fractures: a prospective randomized trial with a minimum of three years of follow-up. J Bone Joint Surg Am 2011;93:159–68.
72. Boyer P, Couffignal C, Bahman M. et alDisplaced three and four part proximal humeral fractures: prospective controlled randomized open-label two-arm study comparing intramedullary nailing and locking plate. Int Orthop 2021;45:2917–26.
73. Schnetzke M, Bockmeyer J, Porschke F, et al. Quality of reduction influences outcome after locked-plate fixation of proximal humeral type-c fractures. J Bone Joint Surg Am 2016;98(21):1777–85.
74. Jost B, Spross C, Grehn H, et al. Locking plate fixation of fractures of the proximal humerus: analysis of complications, revision strategies and outcome. J Shoulder Elbow Surg 2013;22(4):542–9.
75. Jonsson EÖ, Ekholm C, Salomonsson B, et al. Reverse total shoulder arthroplasty provides better shoulder function than hemiarthroplasty for displaced 3- and 4-part proximal humeral fractures in patients aged 70 years or older: a multicenter randomized controlled trial. J Shoulder Elbow Surg 2021;30:994–1006.
76. Laas N, Engelsma Y, Hagemans FJA, et al. Reverse or hemi shoulder arthroplasty in proximal humerus fractures: a single-blinded prospective multicenter randomized clinical trial. J Orthop Trauma 2021;35:252–8.
77. Sebastiá-Forcada E, Cebrián-Gómez R, Lizaur-Utrilla A, et al. Reverse shoulder arthroplasty versus hemiarthroplasty for acute proximal humeral fractures. A blinded, randomized, controlled, prospective study. J Shoulder Elbow Surg 2014;23:1419–26.
78. Boyle MJ, Youn SM, Frampton CM, et al. Functional outcomes of reverse shoulder arthroplasty compared with hemiarthroplasty for acute proximal humeral fractures. J Shoulder Elbow Surg 2013;22(1):32–7.
79. Chalmers PN, Keener JD. Expanding roles for reverse shoulder arthroplasty. Curr Rev Musculoskelet Med 2016;9(1):40–8.
80. Yahuaca BI, Simon P, Christmas KN, et al. Acute surgical management of proximal humerus fractures: ORIF vs. hemiarthroplasty vs. reverse shoulder arthroplasty. J Shoulder Elbow Surg 2020;29(7S):S32–40.
81. Cai M, Tao K, Yang C, et al. Internal fixation versus shoulder hemiarthroplasty for displaced 4-part proximal humeral fractures in elderly patients. Orthopedics 2012;35:e1340–6.
82. Lu V, Jegatheesan V, Patel D, et al. Outcomes of acute vs. delayed reverse shoulder arthroplasty for proximal humerus fractures in the elderly: a systematic review and meta-analysis. J Shoulder Elbow Surg 2023;32(8):1728–39.
83. Shannon SF, Wagner ER, Houdek MT, et al. Reverse shoulder arthroplasty for proximal humeral fractures: outcomes comparing primary reverse arthroplasty for fracture versus reverse arthroplasty after failed osteosynthesis. J Shoulder Elbow Surg 2016;25(10):1655–60.
84. Maier SP, Prabhat AM, Collins JE, et al. Outcomes of reverse total shoulder arthroplasty for proximal humerus fracture versus rotator cuff arthropathy. J Am Acad Orthop Surg Glob Res Rev 2023;7(10).e23.00169.