

High-Energy Proximal Humerus Fractures in Geriatric Patients: A Review

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Abstract

High-energy proximal humerus fractures in elderly patients can occur through a variety of mechanisms, with falls and MVCs being common mechanisms of injury in this age group. Even classically low-energy mechanisms can result in elevated ISS scores, which are associated with higher mortality in both falls and MVCs. These injuries result in proximal humerus fractures which are commonly communicated via Neer's classification scheme. There are many treatment options in the armamentarium of the treating surgeon. Nonoperative management is widely supported by systematic review as compared to almost all other treatment methods. ORIF is particularly useful for complex patterns and fracture dislocations in healthy patients. Hemiarthroplasty can be of utility in patients with fracture patterns with high risk of AVN and poor bone quality risking screw cut-out. Reverse total shoulder arthroplasty is a popular method of treatment for geriatric patients also, with literature now showing that even late conversion from nonoperative management or ORIF to rTSA can lead to good clinical outcomes. Prevention is possible and important for geriatric patients. Optimizing medical care including hearing, vision, strength, and bone quality, in coordination with primary care and geriatricians, is of great importance in preventing fractures and decreasing injury when falls do occur. Involving geriatricians on dedicated trauma teams will also likely be of benefit.

Keywords

geriatric, high energy, elderly, proximal humerus, fracture, trauma

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Introduction

Proximal humerus fractures are common among injuries in geriatric patients. Although 87% of these are from standing height,¹ a substantial number of the remainder likely result from falls from height, motor vehicle collisions (MVCs), and other higher energy mechanisms.² In addition, even classically low energy mechanisms and low-speed MVCs can result in elevated injury severity scores (ISS) or Maximum Abbreviated Injury Scale (MAIS) scores in elderly patients,^{3,4} indicating the increased complexity of care in these patients. Taylor et al showed that mortality increased with ISS among elderly trauma patients and was significantly higher than patients less than 65 (ISS < 15, 3.2% mortality in elderly versus 0.4% non-elderly; ISS 15-29, 19.7% mortality in elderly versus 5.4% non-elderly; ISS ≥ 30, 47.8% mortality in elderly versus 21.7% non-elderly). They concluded that age is an independent risk factor of mortality after stratification for ISS.⁵ Labib and colleagues showed that geriatric patients requiring intubation or transfusion or suffering from head, c-spine, or chest trauma have increased mortality.⁶ Complexity of care is also increased as elderly patients are at risk of delirium; it has been shown that

patients 65 and older develop delirium in the surgical intensive care unit 28.3% of the time, while 45.6% experience delirium some time during their stay or within the 24 hours prior to admission.⁷ Mortality in elderly patients with rib fractures and traumatic brain injuries is also higher than in non-elderly counterparts, adding to complexity.^{8,9} Age has also been associated with hyperglycemia in trauma patients.¹⁰ In patients requiring surgery, geriatric patients are at increased risk of mortality, major perioperative complications, and length of stay.¹¹ These findings showing ISS correlating with mortality and showing elevated mortality and complications in geriatric patients in general stress the importance of interdisciplinary care, communication, and attention to detail.

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Proximal humerus fractures specifically are associated with elevated mortality rates among geriatric trauma patients,¹² further indicating that these are complex injuries in elderly patients. “High-energy” trauma is a term used in the literature without a concrete definition; for our purposes we assume “high-energy” to include injuries with ISS values of 16 or greater not resulting from a same-level fall, as there is some precedent for this in other studies.^{12,13}

Anatomy

Proximal humerus fractures are typically classified based on involvement of four structural elements: the greater tuberosity, lesser tuberosity, shaft, and articular surface. The blood supply to the humeral head is from the anterior and posterior circumflex humeral arteries and their branches. The posterior circumflex supplies the majority of the head, while the anterior circumflex gives rise to the arcuate artery, which runs lateral to the biceps tendon before piercing the head to supply the medial quadrant of the head.¹⁴

Classification

High-energy proximal humerus fractures are classified in the same manner as their low-energy counterparts. The two most common classification systems are the AO/OTA classification, which focuses on intra-articular versus extra-articular location, blood supply/risk of avascular necrosis, and focal versus bifocal pattern¹⁵ (Figure 1). The classic Neer classification (Figure 2) was first described in 1970 and is broken down into 2-part, 3-part, and 4-part injuries based on the greater tuberosity, lesser tuberosity, shaft, and articular surface involvement. This was intended originally to be based on effects of muscle attachment, blood supply to the humeral head, and the condition of the articular surface. It has faced scrutiny for somewhat arbitrary selection of one centimeter and 45 degree cutoffs for segment displacement and has been shown in numerous studies to have limited interobserver and intraobserver reliability. However, it does serve as a time-tested form of communication about fracture types and serves as a “mental picture of the actual pathomechanics and pathoanatomy” to identify each category.¹⁶

Diagnosis

Diagnosis is typically made with plain radiographs in simple two-part fractures, with advanced imaging for more complicated patterns when x-rays are inadequate to develop an appropriate treatment plan¹⁷ (Figure 3). As operative fixation of displaced greater tuberosity fractures can result in meaningful clinical differences¹⁸ and 5 mm displacement is generally considered indication for fixation, CT is often useful for fractures involving the tuberosities and for complex patterns with multiple parts. In cases in which arthroplasty is the treatment of choice, MRI¹⁹ and CT²⁰ have been shown to outperform x-ray in assessing glenoid version.

Management

Probably the most extensive element of proximal humerus literature, high-energy or not, regards management. Nonoperative management, percutaneous pinning, open reduction internal fixation (ORIF), hemiarthroplasty, and reverse total shoulder arthroplasty (rTSA) are all theoretical options for the geriatric patient with a high energy proximal humerus fracture. The high-energy and polytraumatic nature of the situation adds important caveats to treatment decisions as discussed below.

Nonoperative

Nonoperative management has long been considered an option for proximal humerus fractures. A retrospective study in the late 90s showed high patient satisfaction despite low functional scoring and poor reduction in many cases; the authors concluded that nonoperative management of displaced three-part fractures should be considered.²¹ Another similar study retrospectively looked at two-, three-, and four-part fractures and concluded that displaced proximal humerus fractures could be satisfactorily treated by closed methods.²² A systematic review by Iyengar et al showed that in 12 studies on 650 patients, radiographic union was 98% and the average Constant Score was 74. Avascular necrosis (AVN) was reported in only 13 of the 650 cases. The study concluded that nonoperative management demonstrates high rates of healing with good function outcomes.²³ Hanson et al showed that after one year of nonoperative management in 160 patients of an average 63.3 years old, mean difference in Constant Score (8.2) and DASH score (10.2) between the injured and uninjured arm were relatively mild; they concluded that these numbers make it difficult to demonstrate an advantage of operative over nonoperative management of these injuries.²⁴ In addition, a recent JAMA randomized controlled trial (RCT) concluded that fractures involving the surgical neck do not benefit from surgery at 2 years following the injury.²⁵ Interestingly, two large meta-analyses from recent years looking specifically at 3- and 4-part fractures have indicated no clear advantage of operative intervention for proximal humerus fractures.^{26,27}

Other studies have cast more doubt on the utility of nonoperative management. A systematic review from the Journal of Shoulder and Elbow Surgery²⁸ looked at 66 studies including over 2000 patients. They determined that studies were highly variable and included only two studies with randomized groups. They concluded that we are limited in our ability to make clinical conclusions from these data. Other studies have now emerged indicating that operative treatment may have benefit compared to nonoperative treatment for 3- and 4-part fractures, as discussed below.²⁹

Open Reduction Internal Fixation

Multiple ORIF techniques have been compared to nonoperative management. Zyto et. Al. compared a tension band technique to nonoperative management but did not find a significant

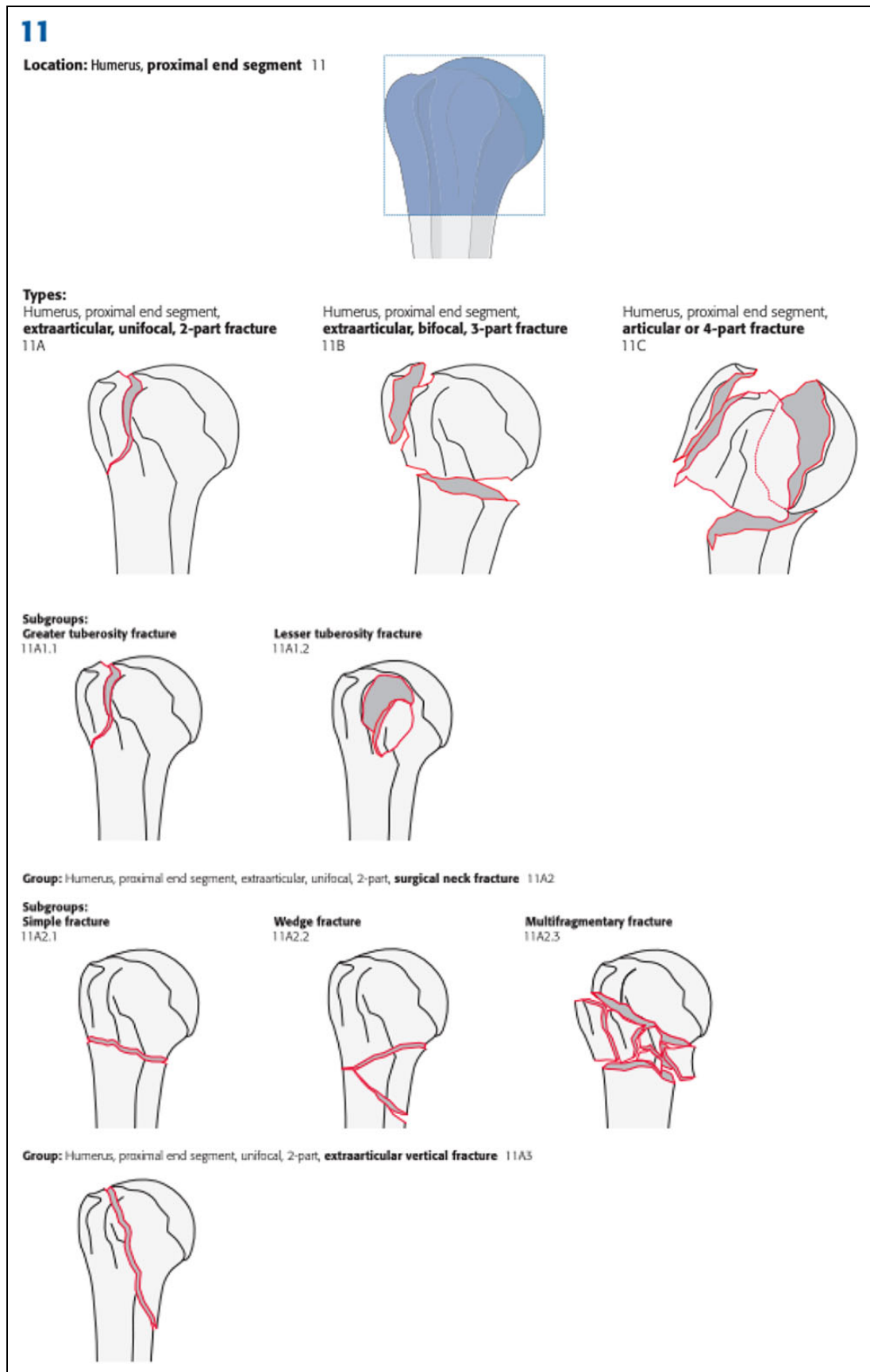


Figure 1. AO/OTA classification of proximal humerus fractures. Reproduced with permission from Meinberg, E. G., et al. "Fracture and Dislocation Classification Compendium—2018." *Journal of Orthopaedic Trauma* 32 (2018): S1-S10.

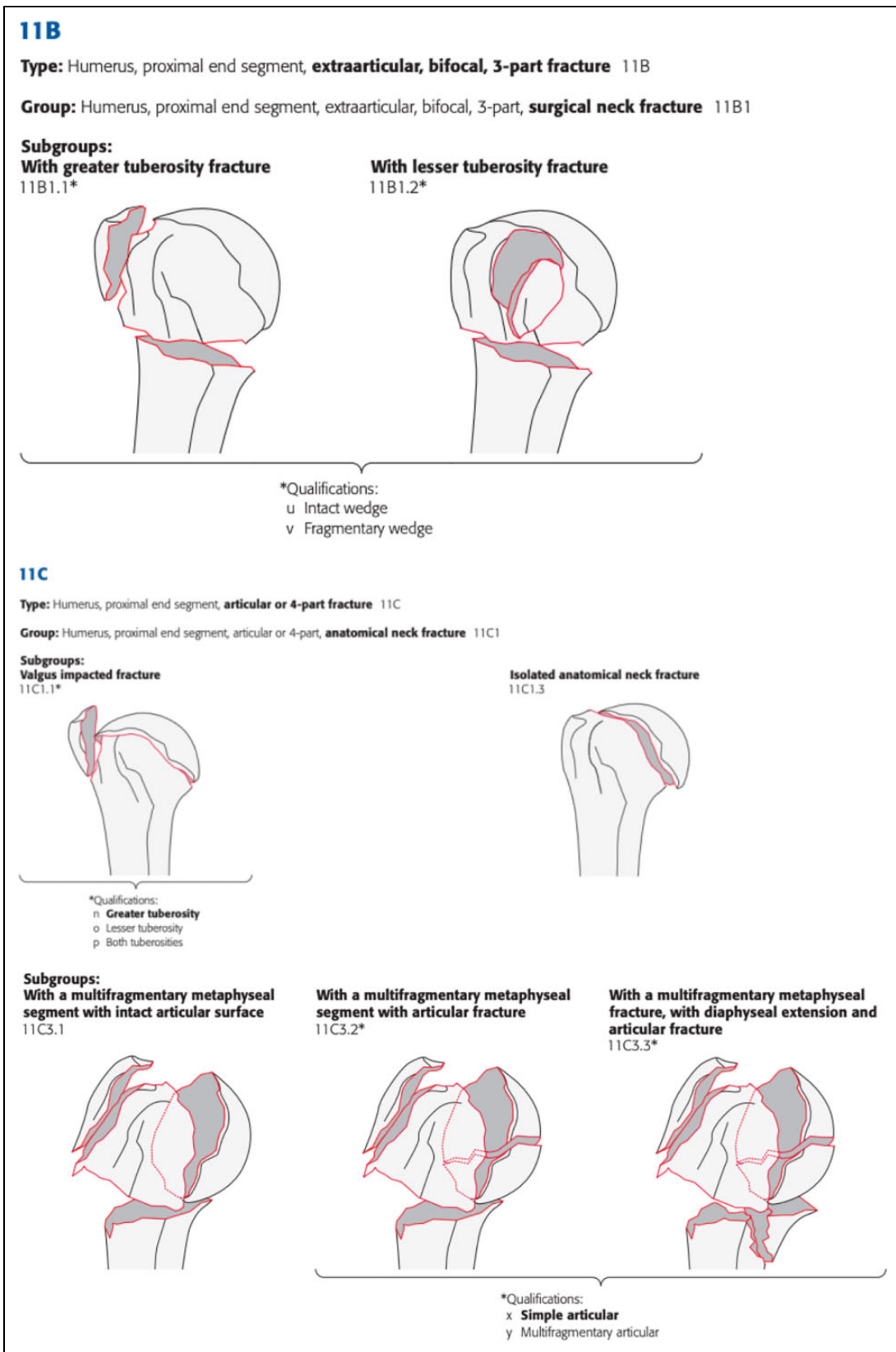


Figure 1. (Continued).

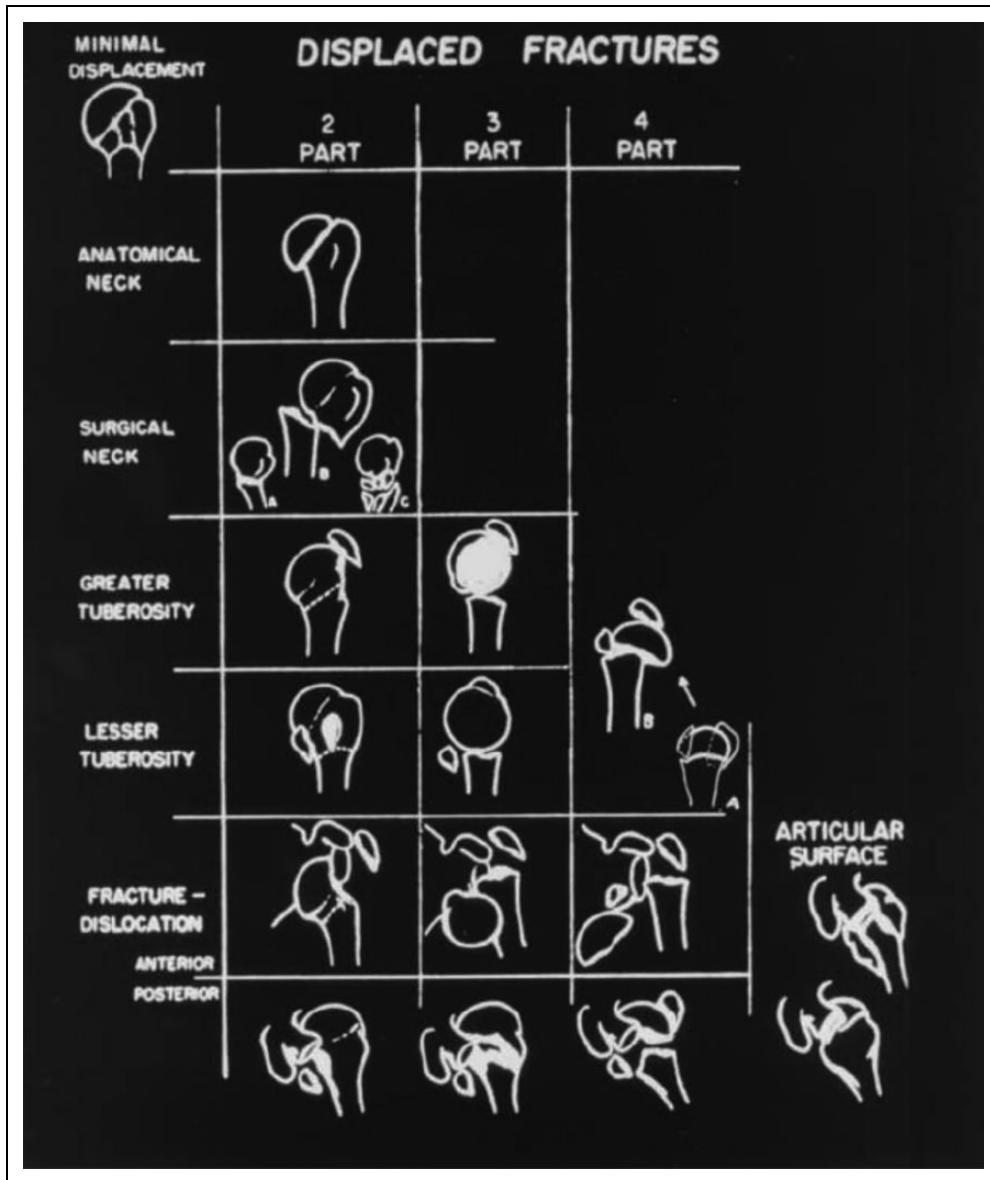


Figure 2. Neer classification of proximal humerus fractures. Reproduced with permission from Neer, Charles S. "Four-segment classification of proximal humeral fractures: purpose and reliable use." *Journal of shoulder and elbow surgery* 11.4 (2002): 389-400.

improvement in functional outcome at up to 5 years.³⁰ A retrospective study on tension bands with an average of 70 months of follow-up found that nonoperative management was superior for 3-part fractures but tension bands are superior for 4-part fractures.³¹

Olerud et al stated in 2011 that ORIF with a locking plate does "indicate an advantage" in function and quality of life, but the statistics were not significant and 30% of the patients needed additional surgery for complications following their ORIF.²⁹ Another study compared locking plates to nonoperative management and found significantly worse range of motion (ROM) and more complications and additional treatment in the locking plate group.³² A randomized clinical trial specifically looking at 3- and 4-part fracture compared to non-operative treatment found no evidence of benefit in

functional outcome or patient self-assessment, as only radiographic outcomes were better in the surgical group.³³ One retrospective study comparing ORIF versus hemiarthroplasty³⁴ did show improved patient-reported outcomes and quality of life scores in the ORIF group for complex articular fractures and fracture-dislocations.

Higher level studies have been performed, assessing the above studies and more.^{35,36} Meta-analysis and systematic review techniques do not identify an advantage of locking plate techniques over nonoperative management, including for 3- and 4-part fractures. Overall, while ORIF may provide some advantages for reconstructible fractures, benefit must be weighed against the high risk of reoperation,²⁹ decreased ROM,³² and risk of anesthesia and inpatient stay in an already-traumatized elderly patient.

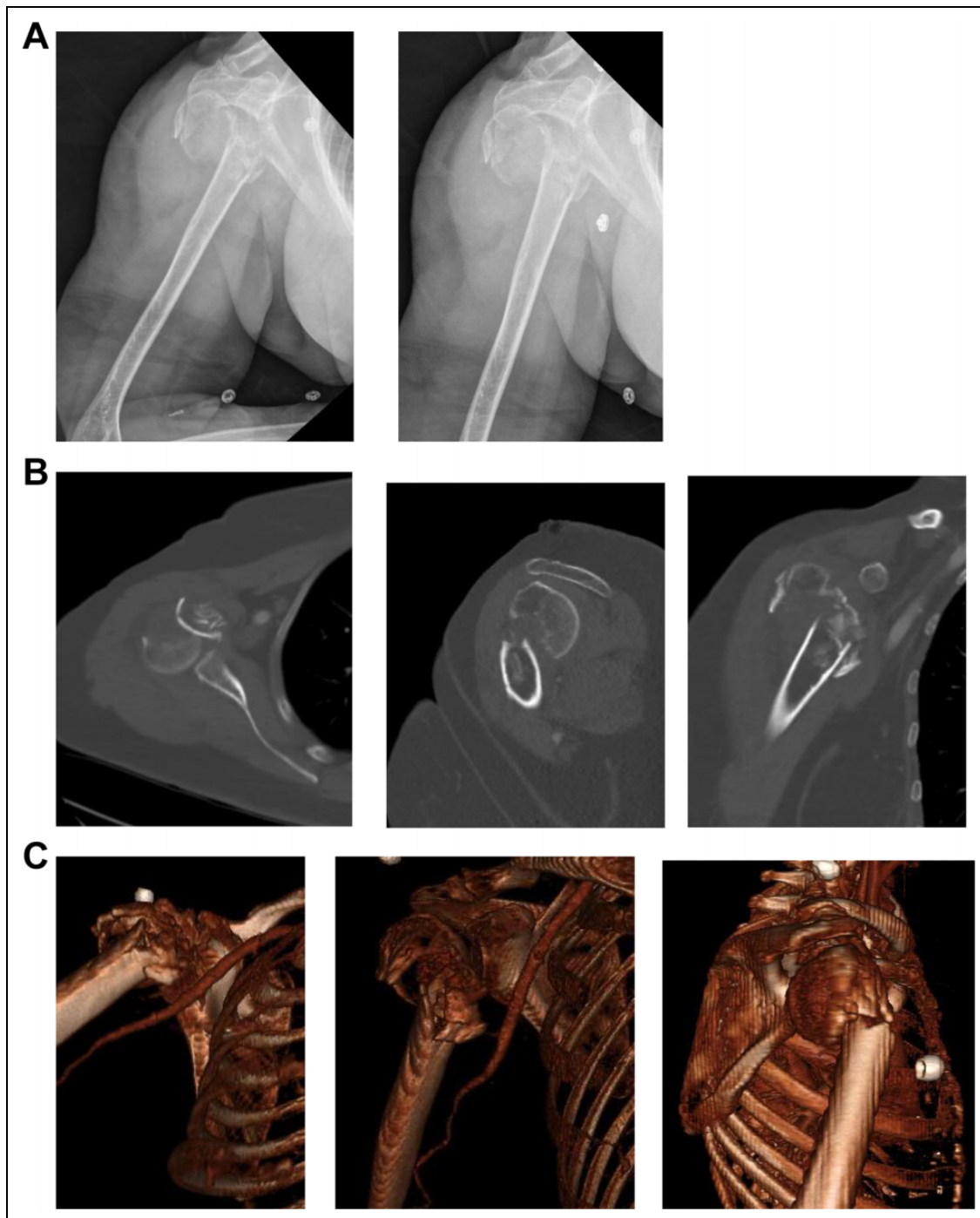


Figure 3. Comminuted proximal humerus fracture as assessed first with A) plain films followed by B) CT with C) 3D reconstruction. CT images show advanced detail useful for operative planning).

Hemiarthroplasty

Hemiarthroplasty can be of utility in the setting of high-energy proximal humerus injuries due to its lack of dependence on articular segment/neck fracture union and the lack of risk of humeral head avascular necrosis and screw cut-out. Multiple studies have been performed to elucidate whether hemiarthroplasty provides an advantage over nonoperative management.

Olerud et al in 2011 compared nonoperative management to hemiarthroplasty in the setting of 4-part fractures in an RCT. They found that health-related quality of life was better at two years in the hemiarthroplasty group, but disabilities of the arm, shoulder, and hand (DASH) scores, Constant scores, and range of motion were not statistically significantly different at two years.³⁷ Boons et al, in a similar RCT assessing 4-part fractures, found no differences in Constant Scores, Simple



Figure 4. Patient from Figure 3 status post reverse total shoulder arthroplasty.

Shoulder Test scores, or pain at 12 months. Abduction strength was better in the nonoperative group at 12 months; they concluded that there are no clear advantages between the two treatment approaches.³⁸

Disadvantages of hemiarthroplasty include the necessity for tuberosity reduction and healing, but revision-free survival has been reported to be over 95% at over 10 years.³⁹ Grogan and Levine summarized in 2017 that hemiarthroplasty remains a cost-effective, durable option for active, older patients at risk for AVN or with unreconstructable fractures.⁴⁰

Reverse Total Shoulder Arthroplasty

rTSA has become a popular management strategy in recent years due to its lack of dependence on the rotator cuff for pain-free function and range of motion (Figure 4). There are now many published studies on its effectiveness in the setting of trauma.

Several recent studies have compared nonoperative management to rTSA. One study compared mortality retrospectively at one year between nonoperative management and rTSA and found no significant difference.⁴¹ A recent prospective RCT found no differences at 12 months for patient reported outcomes with the exception of 1.6 visual analog scale (VAS) pain score in the nonoperative group versus 0.9 in the operative group.⁴² A retrospective study compared nonoperative management with rTSA in 3- and 4-part fractures and found no difference in range of motion or patient-reported outcome.⁴³ A multicenter RTC found that Constant Scores are better at two years with rTSA as compared to nonoperative management with overall small clinical difference.⁴⁴

Regarding rTSA versus other operative managements, one study assessed a prospective cohort of patients undergoing rTSA as compared to retrospective cohorts who underwent ORIF or hemiarthroplasty. They found no differences in simple shoulder test (SST), American Shoulder and Elbow Surgeons

Score (ASES), or short form 12 (SF-12) scores but found significantly more forward flexion and less Medicare cost in the rTSA group.⁴⁵ Multiple other studies systematically reviewed by Mata-Fink et al⁴⁶ have shown that functional outcomes are significantly better with rTSA as compared to hemiarthroplasty,⁴⁷⁻⁵² exceeding the one study in their review⁴⁷ showing a slightly higher DASH score in hemiarthroplasty as compared to rTSA. Interestingly, another recent systematic review⁵³ found no significant differences in ASES or Constant Scores between rTSA and hemiarthroplasty and noted that complications were higher with rTSA, although this review included a prospective study showing better ASES and SST scores and better forward flexion with rTSA as compared to hemiarthroplasty⁵⁴ and a retrospective study including only 20 patients showing no difference in ASES and Oxford Scores.⁵⁵

A practical point in the treatment of proximal humerus fractures in elderly, high-energy trauma patients is that arthroplasty does not have to happen immediately. It is reasonable in a polytrauma patient at high risk for surgery to attempt a trial of nonoperative management followed by late rTSA if nonoperative management fails; these delayed rTSAs have been shown to have no difference in forward flexion, clinical outcome, or all-cause reoperation.⁵⁶ In fact, the delayed group in the study had significantly better external rotation than the acute group. Another study compared acute rTSA versus rTSA to salvage failed ORIF. The salvage group in this study was found to have slightly higher complications but overall no difference in clinical outcome, revision, or reoperation rate. The authors concluded that salvage rTSA after ORIF can still achieve good results.⁵⁷

Future Studies

Several studies are currently underway that will hopefully shed more definitive light on ideal treatment strategies.⁵⁵⁻⁶² RCTs are ongoing to assess nonoperative management, hemiarthroplasty, and rTSA. Perhaps with time these studies will more clearly direct treatment, including for high-energy geriatric patients.

Summary of Management

As noted above, there are many clinically reasonable options for treatment of proximal humerus fractures in the elderly patient (average ages of patients in pertinent treatment studies with open access at the authors' institution listed in Table 1). Nonoperative management is reasonable, with high union rates and low rates of AVN. Nonoperative strategies may be particularly beneficial in the acute, high-energy trauma patient with a proximal humerus fracture who may be at high morbidity and mortality risk with surgery. On the other hand, if the patient is healthy enough for surgery, immediate stabilization or arthroplasty may accelerate rehabilitation, providing overall benefit to the patient. ORIF may provide better radiographic outcomes and hold an advantage for complex intraarticular fractures and fracture-dislocations, but ORIF comes with a high complication rate. Hemiarthroplasty requires union of the tuberosities, but can be a good option for active elderly patients at high risk for AVN or screw cutout. rTSA has been shown in some

Table 1. Average Age Across Pertinent Treatment Studies With Open Access at Authors' Institution.

(Reference) Study	Topic	Mean age (years)
²³ Iyengar, Jaicharan J., et al. "Nonoperative treatment of proximal humerus fractures: a systematic review." <i>Journal of orthopaedic trauma</i> 25.10 (2011): 612-617	Nonoperative Management	65
²⁴ Hanson, Beate, et al. "Functional outcomes after nonoperative management of fractures of the proximal humerus." <i>Journal of Shoulder and Elbow Surgery</i> 18.4 (2009): 612-621.	Nonoperative Management	63.3
²⁵ Rangan, Amar, et al. "Surgical vs nonsurgical treatment of adults with displaced fractures of the proximal humerus: the PROFHER randomized clinical trial." <i>Jama</i> 313.10 (2015): 1037-1047.	Nonoperative Management	66
²⁷ Xie, Lin, et al. "Operative versus non-operative treatment in complex proximal humeral fractures: a meta-analysis of randomized controlled trials." <i>Springerplus</i> 4.1 (2015): 728.	Nonoperative Management	65.6-79.9 in analyzed studies
²⁸ Lanting, Brent, et al. "Proximal humeral fractures: a systematic review of treatment modalities." <i>Journal of shoulder and elbow surgery</i> 17.1 (2008): 42-54.	Nonoperative Management	62.8
²⁹ Olerud, Per, et al. "Internal fixation versus nonoperative treatment of displaced 3-part proximal humeral fractures in elderly patients: a randomized controlled trial." <i>Journal of shoulder and elbow surgery</i> 20.5 (2011): 747-755.	Nonoperative Management	73.9
³⁰ Zyto, Karol, et al. "Treatment of displaced proximal humeral fractures in elderly patients." <i>The Journal of bone and joint surgery. British volume</i> 79.3 (1997): 412-417.	Tension Band	73 operative; 75 conservative
³¹ Ilchmann, T., et al. "Non-operative treatment versus tension-band osteosynthesis in three-and four-part proximal humeral fractures." <i>International orthopaedics</i> 22.5 (1998): 316-320	Tension Band	61 operative; 73 nonoperative
³² Sanders, Rick J., et al. "Locking plate versus nonsurgical treatment for proximal humeral fractures: better midterm outcome with nonsurgical treatment." <i>Journal of shoulder and elbow surgery</i> 20.7 (2011): 1118-1124.	Locking Plate	58 operative; 64 nonoperative
³³ Fjalestad, Tore, et al. "Surgical treatment with an angular stable plate for complex displaced proximal humeral fractures in elderly patients: a randomized controlled trial." <i>Journal of orthopaedic trauma</i> 26.2 (2012): 98-106.	Locking Plate	72.2 operative; 73.1 nonoperative
³⁴ Thorsness, Robert, et al. "Open reduction and internal fixation versus hemiarthroplasty in the management of proximal humerus fractures." <i>Geriatric orthopaedic surgery & rehabilitation</i> 5.2 (2014): 56-62.	ORIF versus Hemiarthroplasty	64.2 ORIF; 69.3 hemiarthroplasty
³⁵ Launonen, Antti P., et al. "Treatment of proximal humerus fractures in the elderly: a systematic review of 409 patients." <i>Acta orthopaedica</i> 86.3 (2015): 280-285.	Tension band, pinning, plating, hemiarthroplasty	72-78 intervention across studies; 72-81 control across studies
³⁶ Sun, Yangbai, et al. "Treatment of complex proximal humeral fracture: plate and tension band fixation versus conservative therapy." <i>International journal of clinical and experimental medicine</i> 8.5 (2015): 7143.	Tension band, plating, conservative management	52.5-75 across studies
³⁷ Olerud, Per, et al. "Hemiarthroplasty versus nonoperative treatment of displaced 4-part proximal humeral fractures in elderly patients: a randomized controlled trial." <i>Journal of shoulder and elbow surgery</i> 20.7 (2011): 1025-1033.	Hemiarthroplasty versus conservative	75.8 hemiarthroplasty; 77.5 nonoperative
³⁸ Boons, Harm W., et al. "Hemiarthroplasty for humeral four-part fractures for patients 65 years and older: a randomized controlled trial." <i>Clinical Orthopaedics and Related Research</i> 470.12 (2012): 3483-3491.	Hemiarthroplasty versus conservative	76.4 hemiarthroplasty; 79.9 conservative

(continued)

Table 1. (continued)

(Reference) Study	Topic	Mean age (years)
³⁹ Antuña, Samuel A., John W. Sperling, and Robert H. Cofield. "Shoulder hemiarthroplasty for acute fractures of the proximal humerus: a minimum five-year follow-up." <i>Journal of shoulder and elbow surgery</i> 17.2 (2008): 202-209.	Long-term results and complications of hemiarthroplasty	66 at time of surgery
⁴⁰ Grogan, Brian, and William N. Levine. "The continuing role of hemiarthroplasty in the treatment of proximal humerus fractures." <i>Seminars in Arthroplasty</i> . Vol. 28. No. 3. WB Saunders, 2017.	Review	N/A
⁴¹ Grogan, Brian, and William N. Levine. "The continuing role of hemiarthroplasty in the treatment of proximal humerus fractures." <i>Seminars in Arthroplasty</i> . Vol. 28. No. 3. WB Saunders, 2017.	rTSA versus conservative	82.2 rTSA; 83.7 conservative
⁴² Lopiz, Yaiza, et al. "Reverse shoulder arthroplasty versus nonoperative treatment for 3-or 4-part proximal humeral fractures in elderly patients: a prospective randomized controlled trial." <i>Journal of Shoulder and Elbow Surgery</i> (2019).	rTSA versus conservative	82 rTSA; 85 conservative
⁴³ Roberson, Troy A., et al. "Nonoperative management versus reverse shoulder arthroplasty for treatment of 3-and 4-part proximal humeral fractures in older adults." <i>Journal of shoulder and elbow surgery</i> 26.6 (2017): 1017-1022.	rTSA versus conservative	71 rTSA; 71 conservative
⁴⁴ Chivot, Matthieu, et al. "Three-and four-part displaced proximal humeral fractures in patients older than 70 years: reverse shoulder arthroplasty or nonsurgical treatment?." <i>Journal of Shoulder and Elbow Surgery</i> 28.2 (2019): 252-259.	rTSA versus conservative	77 rTSA; 79.2 conservative
⁴⁵ Chalmers, Peter N., et al. "Reverse total shoulder arthroplasty for acute proximal humeral fracture: comparison to open reduction–internal fixation and hemiarthroplasty." <i>Journal of shoulder and elbow surgery</i> 23.2 (2014): 197-204.	rTSA, ORIF, hemiarthroplasty	77 rTSA; 71 ORIF; 72 hemiarthroplasty
⁴⁶ Mata-Fink, Ana, et al. "Reverse shoulder arthroplasty for treatment of proximal humeral fractures in older adults: a systematic review." <i>Journal of shoulder and elbow surgery</i> 22.12 (2013): 1737-1748.	rTSA versus hemiarthroplasty systematic review	Range 70-86 rTSA; 69-85 hemiarthroplasty
⁴⁷ Gallinet, D., et al. "Three or four parts complex proximal humerus fractures: hemiarthroplasty versus reverse prosthesis: a comparative study of 40 cases." <i>Orthopaedics & Traumatology: Surgery & Research</i> 95.1 (2009): 48-55.	rTSA versus hemiarthroplasty	74 rTSA; 74 hemarthroplasty
⁵¹ Garrigues, Grant E., et al. "Hemiarthroplasty versus reverse total shoulder arthroplasty for acute proximal humerus fractures in elderly patients." <i>Orthopedics</i> 35.5 (2012): e703-e708.	rTSA versus hemiarthroplasty	80.5 rTSA; 69.3 hemiarthroplasty
⁵² Boyle, Matthew J., et al. "Functional outcomes of reverse shoulder arthroplasty compared with hemiarthroplasty for acute proximal humeral fractures." <i>Journal of shoulder and elbow surgery</i> 22.1 (2013): 32-37.	rTSA versus hemiarthroplasty	79.6 rTSA; 71.9 hemiarthroplasty
⁵³ Ferrel, Jason R., Thai Q. Trinh, and Richard A. Fischer. "Reverse total shoulder arthroplasty versus hemiarthroplasty for proximal humeral fractures: a systematic review." <i>Journal of orthopaedic trauma</i> 29.1 (2015): 60-68.	rTSA versus hemiarthroplasty systematic review	77.1 average rTSA; 70.8 average hemiarthroplasty

(continued)

Table 1. (continued)

(Reference) Study	Topic	Mean age (years)
⁵⁴ Cuff, Derek J., and Derek R. Pupello. "Comparison of hemiarthroplasty and reverse shoulder arthroplasty for the treatment of proximal humeral fractures in elderly patients." <i>JBS</i> 95.22 (2013): 2050-2055.	rTSA versus hemiarthroplasty	74.4 average overall
⁵⁵ Young, Simon W., et al. "Comparison of functional outcomes of reverse shoulder arthroplasty versus hemiarthroplasty in the primary treatment of acute proximal humerus fracture." <i>ANZ journal of surgery</i> 80.11 (2010): 789-793.	rTSA versus hemiarthroplasty	77.2 rTSA; 75.5 hemiarthroplasty
⁵⁶ Torchia, Michael T., et al. "Acute versus delayed reverse total shoulder arthroplasty for the treatment of proximal humeral fractures in the elderly population: a systematic review and meta-analysis." <i>Journal of shoulder and elbow surgery</i> (2019).	Acute versus delayed rTSA	71.8 delayed; not reported for acute
⁵⁷ Shannon, Steven F., et al. "Reverse shoulder arthroplasty for proximal humeral fractures: outcomes comparing primary reverse arthroplasty for fracture versus reverse arthroplasty after failed osteosynthesis." <i>Journal of shoulder and elbow surgery</i> 25.10 (2016): 1655-1660.	Primary rTSA versus RTSA after failed ORIF	75 primary; 70 salvage
⁵⁸ Launonen, Antti P., et al. "Conservative treatment, plate fixation, or prosthesis for proximal humeral fracture. A prospective randomized study." <i>BMC musculoskeletal disorders</i> 13.1 (2012): 167.	Not yet reported	Not yet reported
⁵⁹ Den Hartog, Dennis, et al. "Primary hemiarthroplasty versus conservative treatment for comminuted fractures of the proximal humerus in the elderly (ProCon): a multicenter randomized controlled trial." <i>BMC musculoskeletal disorders</i> 11.1 (2010): 97.	Not yet reported	Not yet reported
⁶⁰ Handoll, Helen, et al. "Protocol for the ProFHER (PROximal Fracture of the Humerus: Evaluation by Randomisation) trial: a pragmatic multi-centre randomised controlled trial of surgical versus non-surgical treatment for proximal fracture of the humerus in adults." <i>BMC musculoskeletal disorders</i> 10.1 (2009): 140. (Handoll, Helen, 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." <i>Health Technology Assessment (Winchester, England)</i> 19.24 (2015): 1.)	Original protocol cited; results reported 2015	66.2 surgery; 65.8 not surgery
⁶¹ Brorson, Stig, et al. "Effect of osteosynthesis, primary hemiarthroplasty, and non-surgical management for displaced four-part fractures of the proximal humerus in elderly: a multi-centre, randomised clinical trial." <i>Trials</i> 10.1 (2009): 51.	Not yet reported	Not yet reported
⁶² Smith, Geoffrey CS, et al. "Reverse Shoulder Arthroplasty for the treatment of Proximal humeral fractures in the Elderly (ReShAPE trial): study protocol for a multicentre combined randomised controlled and observational trial." <i>Trials</i> 18.1 (2017): 91.	Not yet reported	Not yet reported

high-quality studies to have slight advantages compared to nonoperative management or hemiarthroplasty, and rTSA can be performed after the acute clinical phase without compromising long-term results.

The author's preference (Figure 5) is to treat high-risk, frail patients with an initial course of non-operative management. If the patient is healthy enough for surgery and has a

high activity-level at baseline, minimal degenerative change, no pre-injury symptoms, and good bone quality, then ORIF is a reasonable option. If the patient has failed nonoperative management or has a complex injury pattern at high risk of AVN or ORIF failure, hemiarthroplasty or rTSA can be beneficial. This is an historic area of debate with broad terms, but we feel this algorithm provides general guidance.

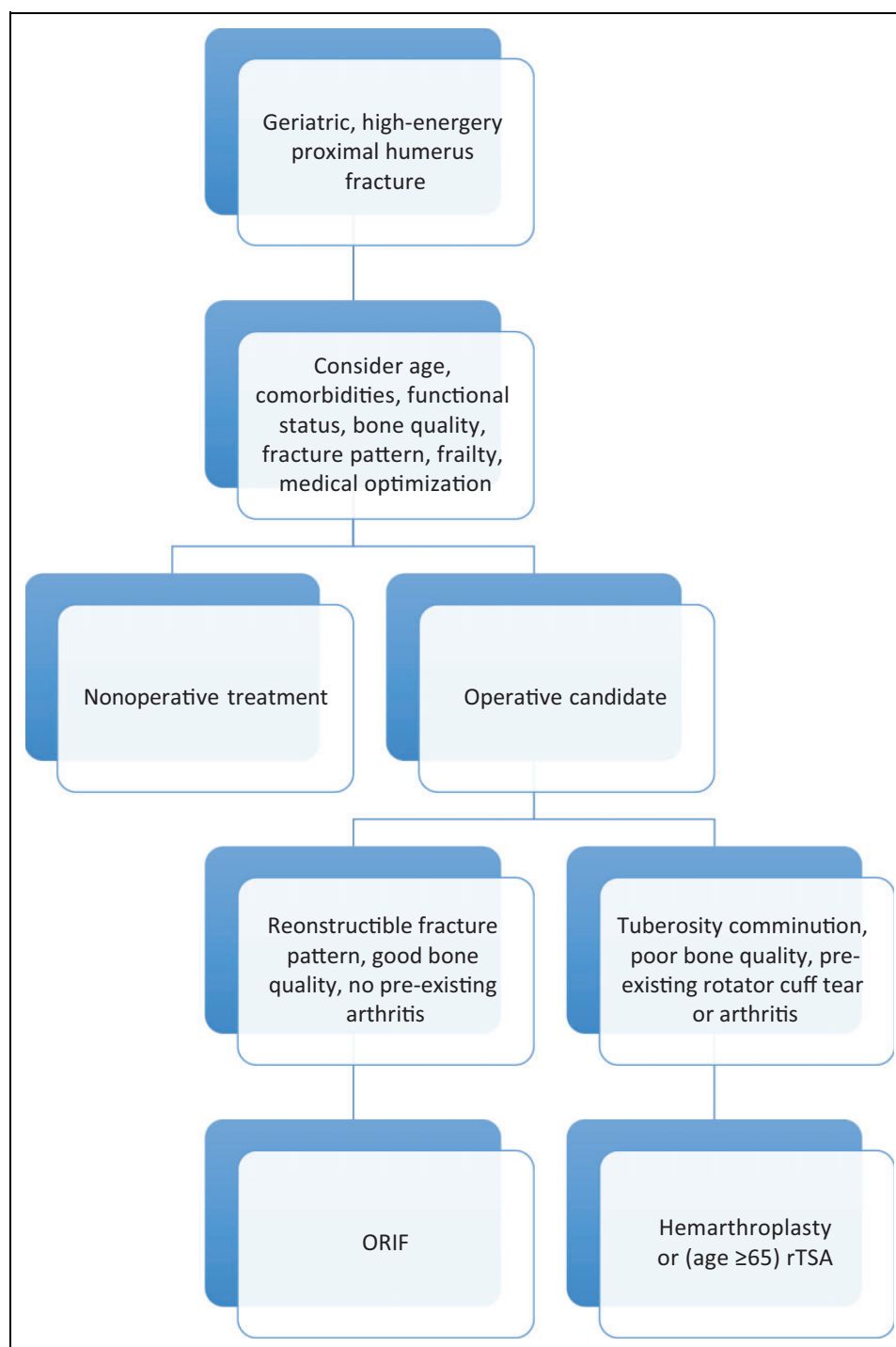


Figure 5. Author's preferred treatment algorithm.

Prevention

As extensive as management options are in treating high-energy proximal humerus fractures in the elderly, prevention of such injuries is clearly superior. Many studies have examined interventions that providers can take to optimize geriatric fitness to prevent falls and MVCs, specifically.

In 2017, around three million unintentional falls occurred in the U.S. prompting evaluation in emergency departments, with

over 870,000 of these patients requiring hospitalization.^{63,64} As noted above, even classically “low energy” mechanisms can lead to high ISS scores in geriatric patients.³ Falls from height and down stairs also result in polytrauma,² making fall prevention a potential key intervention in preventing some cases of polytraumatic injuries in the elderly. The United States Preventive Services Task Force (USPSTF) in its 2018 recommendation statement on fall prevention⁶⁴ recommended “exercise

interventions” in geriatric patients who are at increased risk for falls and recommended for “multifactorial interventions” for the same population. They recommend against vitamin D supplementation for patients who are not known to have osteoporosis and vitamin D deficiency. The recommendation for exercise interventions is based on systematic review of numerous RCTs from the U.S and elsewhere that show in general that three exercise sessions per week for 12 months can reduce fall-related fractures and falls that result in injury.⁶⁵ Multifactorial intervention recommendations are based on similar systematic review of RCTs in which various studies examined any number of components including balance, gait, vision, cardiovascular health, medication, environment, cognition, and psychological health. The reviewers found that individual studies did show reduced rates of falls and/or fall events per person-year, although pooled analysis of studies did not reveal a significant reduction (though it did trend toward a difference at $p = 0.09$). Malnutrition has also been shown to be associated with increased risk of falling and impaired activity in a Dutch study, with percentage of fallers lower in a malnourished group which underwent nutritional intervention ($p = 0.056$).⁶⁶

Motor vehicle collisions are another preventable mechanism of high energy trauma in geriatric patients. In 2017, 7700 adults over 65 years old were killed in MVCs, and over 257,000 were treated in emergency departments. As the population has aged in the United States, as of 2017 we have 44 million licensed drivers over 65, up 63% from 1999.⁶⁷ Fatal crash rates increase notably at age 70-74 and are highest among drivers 85 and older.⁶⁸ Increasing safety of driving in the geriatric population is multifactorial. The Eastern Association for the Surgery of Trauma (EAST) provided an evidence-based review of risk factors and prevention of MVCs in the elderly in 2015.⁶⁹ The group examined car engineering, environmental and behavioral interventions, and risk screening strategies. They noted that the Maximum Abbreviated Injury Scale is more likely to be 3 or higher in elderly patients with lower-severity crashes,⁴ and the authors recommended chest protection measures such as lower force airbags and more adaptable seat restraints. The EAST group noted in their environmental section that simply posting a reminder sign for seatbelt use outside of senior communities can result in improved seat belt use which remains substantial at four years post-intervention.^{70,71} Reducing elderly driving during evening hours may also pose a safety advantage.⁷² Regarding risk screening, the EAST group noted that patients with arrhythmias,⁷³ CAD, and DM⁷⁴ are at increased risk of MVCs. Hearing has also been noted to be related to risk of crash,⁷⁵ and cataract surgery has been shown to cut the crash rate in half compared to cataract patients who did not undergo surgery⁷⁶; reduction in useful visual field also increases crash risk.⁷⁷ Over 70% of elderly trauma patients with a positive alcohol screen were found to be legally intoxicated,⁷⁸ supporting alcohol abuse screening in geriatric drivers. These studies highlight multiple areas orthopaedic surgeons can screen and encourage elderly patients to treat to help ensure they avoid high-energy trauma.

A retrospective study comparing falls to MVCs in elderly patients has shown that falls are a strong predictor of mortality even when compared to MVCs. This study showed that MVC patients had an average ISS of 17.6 versus 5.8 in the fall patients overall, with ISS scores in fatal injuries at 14.2 for fall victims versus 15.1 for MVC patients.⁷⁹ Higher ISS was independently associated with mortality for both injury mechanisms; the authors concluded that trauma triage protocols should identify high-risk elderly patients and that serious consideration should be given to making geriatric specialists members of the trauma team.

Summary

In conclusion, high-energy proximal humerus fractures in elderly patients can occur through a variety of mechanisms, with falls and MVCs being common mechanisms of injury in this age group. Even classically low-energy mechanisms can result in elevated ISS scores, which are associated with higher mortality in both falls and MVCs. These injuries result in proximal humerus fractures which are commonly communicated via Neer’s classification scheme. There are many treatment options in the armamentarium of the treating surgeon. Nonoperative management is widely supported by systematic review as compared to almost all other treatment methods. ORIF is particularly useful for complex patterns and fracture dislocations in healthy patients. Hemiarthroplasty can be of utility in patients with fracture patterns with high risk of AVN and poor bone quality risking screw cut-out. Reverse total shoulder arthroplasty is a popular method of treatment for geriatric patients also, with literature now showing that even late conversion from nonoperative management or ORIF to rTSA can lead to good clinical outcomes. Prevention is possible and important for geriatric patients. Optimizing medical care including hearing, vision, strength, and bone quality, in coordination with primary care and geriatricians, is of great importance in preventing fractures and decreasing injury when falls do occur. Involving geriatricians on dedicated trauma teams will also likely be of benefit.


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