Proximal Humerus Fractures in the Elderly
Are We Operating on Too Many?

Toni M. McLaurin, M.D.

Abstract
Proximal humerus fractures in the elderly are a relatively rare injury, the treatment of which remains controversial, especially regarding Neer displaced two-part, and three-part and four-part fractures. Operative indications for most displaced proximal humerus fractures in the elderly remain poorly defined, but recent literature is actually supporting less aggressive approaches except for the most severe fractures. Recent epidemiological and larger scale retrospective studies fail to show a significant functional difference between operative and non-operative treatment of displaced two-part and three-part fractures in the elderly. Most four-part fractures appear to be best treated with hemiarthroplasty. Recent meta-analyses show a need for well-executed, randomized, prospective studies that can be used to provide evidence-based templates for appropriate management of displaced proximal humerus fractures in the elderly.

Anatomy
The key to classifying and treating proximal humerus fractures is understanding proximal humerus anatomy. Neer described four well-defined parts of the proximal humerus: the greater tuberosity, the lesser tuberosity, the proximal shaft, and the humeral head. The Neer classification of proximal humerus fractures is based on displacement and angulation of these four parts. The significance of these parts lies in the deforming forces that act on them once they are fractured. These forces act as follows: 1. the rotator cuff causes proximal and posterior displacement of the greater tuberosity and medial displacement of the lesser tuberosity and humeral head through the subscapularis; 2. the pectoralis major causes medial displacement of the humeral shaft; and 3. the deltoid causes abduction of the humeral shaft (Fig. 1).

Although the vascular supply does not play a role in Neer’s classification scheme, it is important to understand, as it may help dictate appropriate management by helping to predict the post-fracture vascularity of the humeral head. There are three main contributions to the vascular supply of the humeral head. The arcuate artery, an interosseous vessel that is the terminal branch of the anterior humeral circumflex, is the main arterial contribution to the humeral...
head and perfuses the entire epiphysis. Damage to this vessel requires a more distal anastomosis to compensate for the lack of blood supply. A branch of the posterior humeral circumflex supplies a small portion of the posteroinferior part of the articular surface, and small vessels entering through the rotator cuff insertions also supply inconsistent vascularity to the humeral head (Fig. 2). Both of these supply vascularity to a much lesser degree than the arcuate artery.4

**Classification**

As the Neer classification is based on these four anatomical parts, it is important to obtain adequate and appropriate radiographs to determine the presence of fracture lines, displacement, and angulation. The standard shoulder “trauma series” consists of an AP of the shoulder, a scapular Y view, and an axillary view (Fig. 3). Additional studies, such as internal and external rotation views and transthoracic lateral views, can add more information when the classification is equivocal. According to the Neer classification, displacement greater than one centimeter or angulation of more than 45° is required for classification as a part. Although this classification has been shown to have significant problems with intra-observer and inter-observer variability and reproducibility,11,12 it remains the most widely-used classification of proximal humerus fractures.

The AO classification13,14 (Fig. 4) emphasizes the vascular supply to the articular segment. This classification is generally only used for reporting purposes in the literature, but may have more significance in identifying specific fracture patterns. AO Type A fractures are unifocal, usually involving the greater tuberosity or surgical neck and have no vascular interruption to the articular segment. Type B fractures are bifocal, include some fracture-dislocations, and have an increased risk of avascular necrosis. Type C fractures include all intra-articular anatomical neck fractures, including head-splitting fractures. These fractures involve total vascular dissociation of the articular segment and have a high risk of avascular fractures. There are additional subdivisions to further describe the fractures, but due to both the classification’s complexity and the fact that it has not yet been shown to be predictive of long-term outcomes, its use remains uncommon.

**Current Treatment Recommendations**

The controversy regarding appropriate treatment of proximal humerus fractures increases as the complexity of the fracture increases. Non-displaced or minimally displaced fractures are reported to comprise anywhere from 49% to 85% of all proximal humerus fractures.2-4 Clearly, in the elderly, non-operative management of these injuries is the recommended treatment. The controversy begins when displaced fractures are considered. Current trends in orthopaedics have favored operative management of displaced two-, three-, and four-part fractures. Recommendations for most displaced two- and three-part fractures include internal fixation, with possible prosthetic replacement in three-part fractures that are not amenable to reconstruction.15-18 These include fractures that are severely comminuted or that occur in very osteopenic bone. In the elderly, four-part fractures are generally best treated with hemiarthroplasty, with the exception of the valgus impacted four-part fracture.19,20 This
particular fracture pattern has a significantly lower rate of avascular necrosis than other four-part fractures (20% versus up to 90%) and an attempt at limited internal fixation is recommended.\textsuperscript{19} If adequate fixation is not possible, then treatment with hemiarthroplasty should proceed.

Many different types of internal fixation have been

\textbf{Figure 3} Radiographic shoulder “trauma series” including: AP of the shoulder (A and B note the lack of overlap of the humeral head on the glenoid as compared to the shoulder view seen on an AP chest x-ray); C, scapular Y view; and D, axillary view.
described, and papers are dispersed throughout the literature both supporting and condemning almost every type of fixation. Discussing the indications and contraindications of them all is beyond the scope of this review, but following are many of these fixation options: tension band wiring\textsuperscript{16,21}; modified tension band wiring with Enders rods\textsuperscript{22}; closed reduction and percutaneous pinning\textsuperscript{23}; intramedullary nailing\textsuperscript{24}; and open reduction internal fixation with a variety of plate-and-screw constructs, including standard T-plates,\textsuperscript{18,25} blade plates,\textsuperscript{17} and the newer locking proximal humerus plates.

Complications of proximal humerus fractures can derive from both the fracture itself and from its treatment. One of the most devastating of these complications is avascular necrosis (AVN). The highest rate of AVN occurs with four-part fractures, and, as previously stated, may be as high as 90%. It can also occur in three-part fractures, but since only a portion of the head is involved, the AVN may not be as clinically significant. However, operative treatment can exacerbate this, as increased stripping of fracture fragments during open reduction can increase the proportion of the head that is affected by AVN.\textsuperscript{17,26} Other complications are related to the fact that any attempt at internal fixation involves attempting to get adequate bony purchase in osteopenic bone. These complications include multiple types of hardware failure such as screw cutout, failure of plate fixation, and backing out of intramedullary nails, any of which can result in bony collapse and loss of reduction (Fig. 5). As with all fractures, there is also always the risk of malunion, nonunion, neurologic injury, and vascular injury, all possible either with or without operative intervention.
Are We Operating on Too Many Proximal Humerus Fractures in the Elderly?

As the literature over the past two decades has tended to support, operative management of displaced two-part, and most three-, and four-part fractures, even in the elderly, it is important to critically review the literature regarding these injuries. A review of the literature to try to determine the natural history of non-operative treatment of proximal humerus fractures reveals that many of the repeatedly quoted studies are decades old with multiple flaws and many other aspects that make distilling them all into a single recommendation inappropriate. These studies frequently have different rehabilitation protocols not only in a study-to-study comparison, but often between patients groups within the same study. Most of the studies are nonrandomized, retrospective, comparative, and based on small series with no controls.\(^9,10\) Many have inclusion criteria that allow the results of non-operative treatment of low-energy fractures in elderly patients to be combined with those of young patients with high-energy injuries. Widely varying injury types are often combined. Most importantly, in this era of evidence-based medicine, in many of these studies, when outcomes were actually evaluated, a variety of outcome measures were used, but most of them were not validated.\(^9\)

A systematic review of the literature on treatment of three- and four-part proximal humerus fractures by Misra and colleagues\(^10\) looked at 147 comparative trials and case series over the 30-year period from 1969 to 1999. Inclusion criteria for review included studies evaluating three- and four-part fractures in skeletally mature patients, with a minimum of 15 patients enrolled in each study, treated within 48 hours of injury, with a minimum of 6 months of followup and at least 85% patient followup. Of these

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**Figure 5** This 65-year-old patient had an open proximal humerus fracture-dislocation (A) and underwent irrigation debridement and operative fixation initially with modified tension band wiring (B). This fixation failed (C, AP view) and was revised to a blade plate (D), which also failed (E). The patient developed a post-operative infection requiring numerous repeat debridements, but eventually went on to heal with antibiotic beads but no hardware in place (F).
147 studies, only 24 were eligible for the authors’ review. Twenty-one were case series, three were comparative trials, and only two were randomized, controlled trials. The authors looked at numerous factors to attempt to derive any conclusions from their meta-analysis. The only conclusions they were able to draw were: 1. conservative management compared to either fixation or arthroplasty resulted in more pain and poorer range of motion, although the difference in range of motion when comparing conservative management to fixation was not significant; and, interestingly, 2. restoration of anatomy was not shown to correlate with better functional outcome. These investigators were unable to reach any other conclusions based on the literature, despite the large number of studies they reviewed.

The Cochrane database of systematic reviews, a collection of evidence-based medicine databases, contains a review of interventions for proximal humerus fractures originally performed in 2001, and updated in 2002 and 2003.\(^3,27,28\) Even with updates, only 12 randomized studies on proximal humerus fractures were found in the literature. All were small, with the largest involving only 86 patients. Eight evaluated conservative treatment, three compared conservative treatment with surgery, and one compared two surgical techniques. One of the major conclusions from both this review and that of Misra and colleagues\(^10\) is that no evidence-based decisions regarding appropriate treatment of proximal humerus fractures can be made based on the current literature.

In one of the few randomized, prospective studies in the literature, Zyto and associates looked at three- and four-part fractures in 40 patients with a mean age of 74 years, comparing tension band wiring to conservative treatment.\(^21\) Using the Constant score,\(^20\) pain, range of motion, power, and activities of daily living were assessed. These investigators found no significant difference in function after 1 year between the operative and non-operative groups, with no statistically significant differences in pain, range of motion, abduction/flexion power, or ability to perform activities of daily living. In both groups, little improvement in these outcomes was seen after 1 year. Surgery did improve the position of the fracture fragments, but this did not correlate with any improvement in functional outcome compared to the non-operative patients, plus surgery resulted in more complications. These investigators concluded that, as outcomes were similar but operative treatment had a higher complication rate, conservative treatment should be considered for displaced three-part fractures. Since only three patients in the study had four-part fractures, the authors felt their sample size was too small to draw any conclusions about this fracture type. However, they did note that of the two patients treated non-operatively, both had acceptable functional outcomes.

Ilchmann and coworkers\(^7\) performed a retrospective review of 34 patients, with a mean age of 70 years, in whom three- and four-part fractures were treated either non-operatively or with tension-band wiring. In three-part fractures, they found better pain relief and function with non-operative management, although both forms of treatment resulted in decreased range of motion. All four-part fractures had an overall poor outcome regardless of treatment modality, but tension-band wiring did seem to improve function and motion in these injuries. However, these investigators recommended internal fixation of four-part fractures only for the valgus-impacted fractures. Otherwise, their recommendation was for prosthetic replacement.

A retrospective study by Zyto\(^3\) looked at 17 three- and four-part fractures in 15 patients, with a mean age of 66 years, who were treated non-operatively and followed for a minimum of 10 years. Although the sample size was small, this study is unique in its long-term follow-up. All patients had low Constant scores, but all also had high acceptance of their shoulder condition despite decreased range of motion and weakness. This was believed to be most likely due to the fact that only four patients reported mild pain, and the rest, including all of the patients with four-part fractures, had no pain. As radiographs showed that only 3 out of 17 of these fractures had acceptable alignment, and only 7 showed the greater tuberosity in an acceptable position, the author concluded that there was no clear relationship between fracture reduction, functional outcome, and patient satisfaction.

In 2001, Court-Brown and colleagues\(^2\) revisited the Neer classification in an epidemiological study of 1,027 proximal humerus fractures. They concluded that certain fracture patterns were missed using the Neer classification, including the most common fracture type seen: the impacted bifocal fracture (AO 11-B1.1) (Fig. 6). This fracture pattern represented nearly 15% of all proximal humerus fractures, while Neer three- and four-part fractures combined accounted for only 13% of proximal humerus fractures, with the rare four-part fracture occurring in only 3% of the 1,027 fractures evaluated. This type B1.1 fracture may be represented by a minimally displaced fracture, a displaced

![Figure 6 AO Type B1.1 impacted bifocal fracture.](Image)
two-part surgical neck fracture, a displaced two-part greater tuberosity fracture, or a three-part variant with significant displacement of both the surgical neck and greater tuberosity with valgus impaction (Fig. 7). In a retrospective review evaluating this specific fracture pattern, Court-Brown and associates reviewed 125 patients with B1.1 fractures with a mean age of 71 years who all had a valgus impacted B1.1 fracture treated non-operatively. All fractures united with 80.6% good to excellent results at one year using the Neer criteria. There was a greater improvement in subjective than objective measures. The patients averaged only 75% abduction and flexion power and had markedly limited internal and external rotation after one year, with mean power just over 70% of normal. However, subjectively patients perceived their strength as greater than 90% of normal in all fracture patterns except the three-part variant, in which power was still perceived at greater than 85% of normal. Full glenohumeral movement or power clearly is not required for elderly patients to return to routine activities. Comparing their results to those of other studies evaluating both operative and non-operative management, the investigators concluded that there was little evidence that operative treatment of impacted valgus three-part fractures in the elderly provides any benefit and they recommended non-operative management.

Figure 7 Different types of B1.1 fractures including a minimally displaced fracture (A), a displaced two-part surgical neck fracture (B), a displaced two-part greater tuberosity fracture (C), or a three-part variant with significant displacement of both the surgical neck and greater tuberosity with valgus impaction (D). (Reprinted with permission from: Court-Brown CM, Cattermole H, McQueen MM: Impacted valgus fractures (B1.1) of the proximal humerus: The results of non-operative treatment. J Bone Joint Surg Br 84(4):504-508, 2002.)

Figure 8 AO Type A3.2 translated two-part fracture.
Despite the large number of studies addressing management of displaced proximal humerus fractures in the literature, most of them refer to three- and four-part fractures. A prospective study of 126 displaced two-part fractures followed for five years in patients with a mean age of 72 years showed interesting results. All patients had a translated two-part fracture (AO 11-A3.2) (Fig. 8), which, based on the investigators’ previous epidemiological study, represents 12.7% of all proximal humerus fractures. Most of the patients had greater than 67% translation plus posterior angulation. All fractures were treated non-operatively; all united (Fig. 9) and all had a high Neer score at one year. As with previous studies, the patients’ subjective view of their progress was better than the objective measures. Good or excellent results were seen in 64.5% of patients. There was no correlation between translation or angulation and a patient’s ability to return to daily activities. These patients were compared to an operative cohort, also with at least 66% translation, and there was found to be no difference in Neer scores at one year. Surgery did not improve outcomes regardless of the amount of initial translation. Based on these results, these investigators do not recommend internal fixation of any two-part fractures in the elderly regardless of degree of initial displacement.

**Conclusions**

Despite the large number of retrospective reviews and case series detailing results of operative treatment of proximal humerus fractures, newer literature is trending toward support of non-operative treatment of displaced two-part fractures and most three-part fractures, as there appears to be no difference in functional outcomes with operative versus non-operative treatment. The treatment of choice for four-part fractures remains unclear – partly due to their low incidence in most studies – but current literature continues to support operative treatment of four-part fractures in the elderly. Limited open reduction internal fixation is recommended for the stable four-part valgus impacted fracture and hemiarthroplasty for more unstable four-part fractures including head-splitting fractures, anatomic neck fractures, and head impression fractures. Results in the literature continue to show that, although no one has matched Neer’s results, hemiarthroplasty for four-part fractures can provide predictable pain relief, but unpredictable function. Well-designed, multicenter, prospective, randomized studies are needed to provide true evidence-based treatment recommendations for these complex and controversial injuries.

**References**


