Three-and Four-Part Proximal Humerus Fractures
Evolution to Operative Care

William Min, M.D., M.S., M.B.A., Roy I. Davidovitch, M.D., and Nirmal C. Tejwani, M.D.

Abstract
The recent increase in life expectancy is expected to bring about a concurrent rise in the number of proximal humerus fractures. Those presenting with significant displacement, osteoporosis, and comminution present distinct clinical challenges, and the optimal treatment of these injuries remains controversial. As implant technologies and treatment strategies continue to evolve, the role and appropriateness of certain operative and nonoperative treatment modalities are being debated. Prior concerns regarding humeral head viability forced many physicians to abandon operative management in favor of nonoperative modalities. However, with greater appreciation and understanding of the factors governing humeral head viability, operative intervention is increasingly used and investigated. Nevertheless, sub-optimal results with earlier implants continue to cloud the debate between nonoperative and operative treatment modalities. This paper will review historical considerations, biologic considerations, and implant considerations in the management of three-and four-part proximal humerus fractures.

Proximal humerus fractures account for approximately 5% of all fractures and represent the third most frequent fracture of the elderly.1 Most commonly related to osteoporosis,2 these fractures are often associated with elderly co-morbidities that increase their risk for low-energy falls, such as medication, poor vision, and loss of protective reflexes. However, unlike many osteoporotic fractures, proximal humerus fractures can also occur in the fit elderly.1 Due to the anticipated increases in life expectancy, the number of elderly proximal humerus fractures is expected to triple by 2030.4

A significant majority (85%) of these fractures are minimally- or non-displaced4 and are generally treated nonoperatively.5 However, controversy exists regarding the optimum treatment for displaced fractures. Treatment options range from nonoperative to operative modalities. Recent meta-analyses and larger retrospective and prospective series have not shown an advantage of one treatment modality in the management of all displaced fractures.3,6-8 Adding to this debate, newer implant technologies have challenged the conventional thinking regarding management of displaced proximal humerus fractures. This paper, written in two parts, will examine the evolution of treatment of proximal humerus fractures, and the role that newer implant technologies have played in changing this paradigm.

Nonoperative Management
As early as 180 AD, Galen described his treatment of proximal humerus fractures and fracture-dislocations.9 After reduction by traction-countertraction methods, the extremity was immobilized with a valgus mold.9 Because there were no effective operative methods available, this was considered the first described form of treatment for highly comminuted and unstable proximal humerus fractures. Subsequently, nonoperative management continued to serve as the treatment of choice for highly comminuted or unstable proximal humerus fractures, due to lack of effective surgical technologies and concerns regarding humeral head viability.

Existing literature5,7,10-12 has generally supported nonoperative management; however, while minimally displaced and non-displaced fractures are preferentially and successfully treated using nonoperative methods with good results,5,7,10-12
the studies evaluating the role of nonoperative management in severely comminuted proximal humerus fractures are non-validated, non-randomized, and inconclusive.4

Zyto retrospectively investigated the clinical and radiographic results of displaced three- and four-part displaced fractures treated nonoperatively and followed for a minimum of 10 years, and found that, despite poor functional scores and non-anatomic reductions radiographically, all patients report high contentment with their outcomes.6 However, Zyto’s recommendations for nonoperative treatment were reserved for three-part fractures, as the four-part fractures demonstrated more disability than the three-part group. Lill examined the role of nonoperative management in two- and three-part fractures and found that over 60% of their patients had good and excellent Constant scores. However, similar to Zyto’s study,6 four-part fractures uniformly had poor outcomes and poor Constant scores, mostly attributed to avascular necrosis of the humeral head and resulting arthrosis.13

Based on these findings and in light of our current treatment strategies, nonoperative treatment for displaced three- and four-part fractures is currently reserved for individuals who are medically contraindicated for surgery or have low-demand lifestyles where the risks of surgery outweigh its benefits. While these studies suggest that nonoperative treatment is better suited for three-part fractures (as compared to four-part fracture), nonoperative treatment in these highly displaced fractures may result in significant functional impairment, shoulder stiffness, and malunion.15

Humeral Head Viability and the Evolution to the Role of Operative Treatment

Despite the potential limitations of nonoperative management for highly displaced fractures, it was historically held as the preferred treatment option due to concerns for humeral head viability. Traditionally, nonoperative measures were preferred since it was believed that operative management may disrupt humeral head blood flow and accelerate avascular necrosis.15 With the predominant blood supply of the humeral head coming from the arcuate artery (a branch existing lateral to the bicipital groove and originating from the anterior humeral circumflex artery), earlier surgical techniques potentially had a higher risk of disrupting this critical blood supply. This was evident in the higher rates of avascular necrosis after operative treatment of four-part fractures seen in earlier series.16

However, Neer’s results were the first to suggest that nonoperative management of these fractures was a poorer alternative than operative treatment.16 This finding, coupled with improved surgical techniques and implant options, began to challenge the notion that operative treatment was a poor option for displaced fractures. Additionally, improved understanding regarding the factors and risks for humeral head avascular necrosis lead to further understanding and improved fracture management. While the association between fracture pattern and avascular necrosis rate has not yet been clearly established,17 it is clear that poor surgical techniques can increase the risk of avascular necrosis in three-part fractures to that seen in four-part fractures.18 This further clarifies Neer’s original theory, where he believed that three-part fractures did poorly due to poor surgical technique and inadequate reductions while four-part fractures did poorly due to avascular necrosis.16 While Neer’s original theory had led him to recommend operative fixation for three-part fractures with proper surgical technique and arthroplasty for four-part fractures,16 other investigators now argue that, despite the higher incidence of avascular necrosis in four-part fractures as compared to three-parts,19,20 the decision to treat with operative fixation versus arthroplasty should ideally be based on multiple factors (including patient age and activity level, treatment goals, and medical co-morbidities).

Currently, reported rates for avascular necrosis vary from 3% to 37%.17 In that regard, to minimize these rates, an accurate assessment of humeral head vascularity is crucial in determining both the viability and the prognosis following a proximal humerus fracture. The Hertel criteria employs radiographic markers to determine the adequacy and quality of humeral head vascularity by examining the extent of metaphyseal extension of the proximal humerus fracture and the amount of medial hinge disruption.22 The investigators found that the integrity of the medial hinge and the length of the posteromedial metaphyseal head extension were key predictors of vascular disruptions. Specifically, metaphyseal head extension less than 8 mm and medial hinge disruption greater than 2 mm were good predictors of humeral head ischemia. Recently, Crosby, using tetracycline labeling for displaced three- and four-part fractures, demonstrated a high rate of vascular preservation, especially in younger patients in the anterosuperior aspect of the humeral head.17 In addition to examining the fracture pattern as recommended by Hertel, an adequate understanding of the humeral head vascular anatomy, surgeon expertise, the patient’s physiologic status, activity level, and expected outcome should all be collectively considered to maximize patient outcomes and minimize humeral head necrosis.17

Operative Modalities

The gradual shift to operative treatment of these complex fractures was spurred by both an improvement in implant technologies and techniques, along with concurrent increases in patient and surgeon expectations for improved functional outcomes. The introductions of locking plates and reverse shoulder arthroplasties (RSA) have expanded the options available for treatment, while concurrently generating further controversy.

Closed Reduction and Percutaneous Pinning

The advantage of closed reduction and percutaneous fixation is that it can be performed with minimal surgical dissection and can potentially decreased risk of humeral head...
vascular supply disruption. Resch reported percutaneous fixation of three- and four-part fractures in 27 patients and found that at an average of 24-months follow-up all three-part fractures demonstrated good to very good functional results without avascular necrosis. Good radiographic results were achieved in the four-part fractures but only when they initially presented in a valgus-impacted manner. The investigators concluded that the medial periosteum serves as both an important source of vascular supply and as a hinge for reduction maneuvers (Fig. 1).

This is a technically demanding procedure, especially for more complex proximal humerus fractures. It is a reasonable alternative for AO type A fractures with greater than 66% translation and combined cortical thickness greater than 4 mm, but may not be as good an option in osteoporotic bone and comminuted fractures since this technique requires adequate cortical purchase.

**Intramedullary Nail Fixation**

The use of antegrade intramedullary nail fixation for displaced proximal humerus fractures has been reported as an alternative method of treatment to perform stable fixation with minimal soft tissue dissection. Some investigators have also argued that in addition to the preservation of the periosteal blood supply, intramedullary techniques limit operative time, surgical exposure, and length of hospital stay.

Most studies that have been published on these implants have investigated their use in displaced proximal humerus fractures with an intact head fragment. In a prospective study by Stedtfeld, 112 consecutive patients with displaced fractures were treated and evaluated. The investigators found good functional results in two- and three-part fractures. However, the investigators had a 16% complication rate. They reported that, in four-part fractures, a substantial risk of post-operative complications and bad functional results exist.

Koike evaluated 54 patients with two-, three-, and four-part fractures treated with intramedullary nailing and found that none of the patients developed avascular necrosis. Seventy-nine percent of patients reported satisfactory to excellent results. However, only three of their treated patients had four-part fractures.

Adedapo and Ikpeme evaluated the role of intramedullary nail fixation in three- and four-part fractures. At the one-year follow-up, the median Neer scores were 89 and 60 for the three- and four-part fractures, respectively. However, 13% of their patients, all of whom were in the four-part group, continued to have significant pain at final review. Complications noted in their series included proximal screw loosening and extrusion in three patients and avascular necrosis in one patient. The use of intramedullary implants is not ideal for four-part or osteoporotic fractures.

**Open Reduction Internal Fixation with Locking Plate**

With the advent of locked plates, this technology was applied to the proximal humerus to provide the advantages of a fixed-angled implant without the difficulties and limitations of first generation fixed angle (blade plate) fixation.
Currently, most of these implants are precontoured to the anatomy of the lateral proximal humeral metaphysis and function as an internal fixator providing angular stability (Fig. 2). Advantages of these implants include the ability to obtain anatomic reduction with less fracture devitalization, preservation of the rotator cuff integrity, ability to maintain stable fixation in the face of significant comminution and osteoporosis, and multi-angle screw fixation. In a biomechanical cadaveric study performed by Siffri, simulated humerus neck fractures subjected to cyclic loading comparing locking plate constructions to blade plates demonstrated significantly greater torsional stiffness of locking plates and similar bending stability between the two. Weinstein and coworkers found similar results, and Edwards and colleagues noted that a locking plate was far superior to a proximal humerus nail in both varus bending and torsional stability. Given that most proximal humerus fractures fail secondary to rotational and bending moments, such added stability potentially prevents many of the failures noted with other implant types.

Despite these promising biomechanical results, early clinical studies evaluating the results of proximal humerus locking plates were mixed. Kettler reported on 225 fractures treated with the PHILOS (Synthes, Stratec Medical Ltd, Mezovico, Switzerland) proximal humerus locking plate. In their series, the investigators reported a high rate of complications resulting from technical error, including malreduction (14%), screw perforations (11%), and implant dislocations (4.5%). Similarly, Bjorkenheim and Fankhauser reported hardware failure, nonunion, avascular necrosis, and malunion as complications in their series using the PHILOS plate.

Later studies utilizing the plate demonstrated more promising results. Moonot evaluated the PHILOS plate in 32 patients with displaced three- and four-part fractures, with an average age of 59.9 years. Distinct from previous studies, the investigators addressed bone defects with bone graft substitutes, while tuberosity displacement was treated with anatomic reduction. As a result, the mean Constant score was 66.5, without significant differences in outcomes when comparing patients below and above 60 years of age. They demonstrated a 6% malunion rate and a 3% rate of nonunion and avascular necrosis. Similar findings were also found by Papadopoulos. However, Shahid, however, found that those who were elderly or had fracture-dislocations performed slightly poorer with this fixation.

Other studies examining the use of locking-plate constructs in three- and four-part fractures demonstrated comparable results. Hente noted a 16% rate of avascular necrosis; however, their study did include fracture-dislocations (which were responsible for 80% of these complications). Complications in their series were related to hardware, including greater tuberosity displacement and screw loosening. Hente strongly recommended this construct with tension band wiring of the tuberosities as an alternative to prosthetic replacement. Hirschmann found, at one year postoperatively, that the range of motion of the injured side was 80% that of the contralateral side. Moreover, absolute and relative Constant scores significantly improved from six-months (average 56) to twelve-months (average 65) postoperatively. One over-
riding concept that can be garnered from these studies is the importance of intra-operative reductions, particularly of the tuberosities on functional outcomes.\textsuperscript{54-55}

Solberg retrospectively examined 70 patients older than 55 years of age with three- or four-part proximal humerus fractures treated with locked plates.\textsuperscript{47} His study identified two groups based on the initial direction of the humeral head deformity: those with varus deformity and those with valgus deformity. Complications of avascular necrosis, humeral head perforation, loss of fixation, tuberosity displacement, and varus subsidence were encountered in 79% of those with varus deformity as compared to 19% of those with valgus deformity. Constant scores for all three-part fractures were also significantly better than four-part fractures, but differences between the varus and valgus subgroups were only significant for the three-part group (p < 0.01, as compared to p = 0.19 for the four-part subgroups). The investigators felt that, because the locking plate functions as a tension band by "pulling" the humeral head out of varus, the initial varus malalignment placed the implant at a distinct mechanical disadvantage (especially in osteoporotic bone). Solberg also found that fractures with metaphyseal segment length of less than 2 mm had a higher risk of developing avascular necrosis. The investigators concluded that the angulation of the initial deformity and the length of the metaphyseal segment attached to the articular fragment have a significant influence on final outcomes in these fractures.

Agudelo and coworkers examined the predictors of loss of fixation in proximal humerus locking plate fixation.\textsuperscript{48} In their series, the overall incidence of loss of fixation was 13.7%. They found that there was a statistically significant association between varus malreduction and loss of fixation (30.4% when the head-shaft angle was below 120° versus 11% when the head-shaft angle was greater than 120° [p = 0.02]). Similarly, Lee attempted to determine the prognostic factors for successful clinical outcomes.\textsuperscript{49} They concluded that delay in rehabilitation and decreased head-neck shaft angle, caused by lack of medial support, were the primary factors that led to poor outcome. Other investigators, such as Micic\textsuperscript{50} and Clavert,\textsuperscript{51} also found that early post-operative failures of the locking plate were associated with initial mal-reduction, poor operative technique (including inadequate screw length or plate positioning), loss of medial support, and failure to adequately fix the tuberosities.

**Prosthetic Replacement**

The use of primary arthroplasty in displaced three- and four-part proximal humerus fractures was first proposed by Neer.\textsuperscript{16} Non-locking internal fixation gave mixed results, and concerns regarding avascular necrosis compelled many surgeons to treat complex fractures primarily with arthroplasty options.\textsuperscript{16,24,52-54} With improved fixation implants available, arthroplasty has become reserved for treating fractures that are more technically demanding to reconstruct (i.e., four-part fractures with complex fracture patterns and significant articular involvement, especially in patients older than 60 years of age and head splitting fractures). However, functional results are only moderately satisfactory, despite predictable pain relief.\textsuperscript{55} With the increasing popularity of reverse shoulder arthroplasties (RSA), the role of arthroplasty has been revisited. Regardless of which primary arthroplasty option is selected, aseptic loosening, periprosthetic fractures, infections, and dislocations can occur and must be considered.\textsuperscript{24}

**Hemiarthroplasty**

The indications for hemiarthroplasty in the management of proximal humerus fractures, although evolving due to the advent of locking-plate implants, have traditionally been for four-part fractures, three-part fractures in older patients with poor bone quality, fracture-dislocations, head-splitting fractures, and fractures involving greater than 40% of the articular surface.\textsuperscript{56-58} Concerns regarding the higher rates of avascular necrosis in four-part fractures and the tenuous fixation of fracture fragments in osteoporotic bone have led most surgeons to advocate hemiarthroplasty as the preferred option over internal fixation (Fig. 3).\textsuperscript{56} Valgus-impacted four-part fractures demonstrate a significantly lower rate of avascular necrosis and thus are an exception to this preference for hemiarthroplasty.\textsuperscript{59}

Recent studies have demonstrated that, despite predictable pain relief, hemiarthroplasty provides inconsistent functional outcomes.\textsuperscript{55,60,61} These findings are in contrast to earlier studies that demonstrated more reliable functional results.\textsuperscript{56,57,62-63} It has been shown that early passive range of motion post-operatively, followed by long-term active range of motion and strengthening, is essential to achieve optimal outcomes after shoulder hemiarthroplasty.\textsuperscript{62,64,65} However, the insufficient bony healing of displaced tuberosities after intra-operative fixation at the stem of the prosthesis, malpositioning of the tuberosity fragments, and incorrect positioning of the prosthesis are probably the most important factors determining the outcomes of this treatment modality.\textsuperscript{24,36,64,66,67}

Approximately 4% to 50% of shoulders treated with hemiarthroplasty experience malunion or nonunion of tuberosity fixation, resulting in the most significant complication after hemiarthroplasty for proximal humerus fractures.\textsuperscript{58,65,66} A recent multicenter study by Kralinger and associates revealed that tuberosity positioning is a significant factor in the functional outcome of hemiarthroplasties for fractures of the proximal humerus; however, pain did not correlate with displacement of the tuberosity.\textsuperscript{62} These findings were also reported by Mighell\textsuperscript{57} and Coleman\textsuperscript{59} in their reviews. Aside from devascularization and inadequate fixation that may lead to tuberosity nonunion, Boileau determined that the factors most commonly associated with tuberosity malunion include poor intra-operative positioning of the prosthesis, age, sex, and initial malposition of the greater tubosity.\textsuperscript{68}

Due to importance of anatomic restoration of humeral head position, studies have assessed the use of intra-operative...
anatomic landmarks, such as the bicipital groove, to determine the appropriate 30° to 40° of retroversion for prosthesis orientation. Christoforakis and colleagues proposed using the contralateral humerus to estimate the proper retroversion for each patient as an individualized approach to restoring native anatomy. However, a recent study by the same investigator has found that, when evaluating the mean Constant scores using these two techniques, there is no difference. However, the results of this study are limited secondary to its small sample size.

Use of bony landmarks when assessing for proper prosthesis orientation is limited by the distortion that occurs in complex fractures. Murachovsky validated the use of the pectoralis major tendon as a reproducible landmark for accurate restoration of humeral height with hemiarthroplasty reconstruction. By dissecting 40 cadaveric shoulders, he determined that the distance between the upper border of the pectoralis major tendon insertion on the humerus and the top of the humeral head averaged 5.6 cm ± 0.5 cm. This provides an easily reproducible intraoperative check of prosthetic humeral head height.

The third factor influencing outcome with arthroplasty is the union of the tuberosities. A cadaveric study by de Wilde examining the strength of fixation of the bone-tendon interface of the rotator cuff to the articular rim of the hemiarthroplasty prosthesis found that it is strong enough to resist fracture fragment displacement under forces associated with activities of daily living. Frankle and colleagues determined that circumferential cerclage around the tuberosities decreases interfragmentary motion and strain, maximizes fracture stability, and facilitates post-operative rehabilitation. However, Pijls and associates presented a new sling technique for tuberosity fixation in uncemented hemiarthroplasty for severe fractures of the proximal humerus, due to concerns regarding suture damage from the edges of the drill holes in traditional tuberosity fixation techniques. The investigators felt that in some cases the sutures placed by standard drill holes failed due to suture cut-out through osteoporotic bone, leading to suboptimal tuberosity positioning. The investigators found that their sling technique provided better tuberosity positioning, stable fixation (which they felt translated to improved functional outcomes), patient satisfaction, and pain scores as compared to traditional drill-hole techniques.

Heterotopic ossification, glenoid degeneration, prosthetic loosening, and axillary nerve injury may also be seen with hemiarthroplasty treatment. Reported rates of heterotopic ossification range from nine to 56%. While the studies do not specifically indicate a reason for this difference, it has been shown that patients with hemarthrosis or concomitant rotator cuff tears have a significantly higher risk of heterotopic ossification. Mighell and coworkers have also reported an 8% rate of glenoid degeneration at an average of three-year follow-up, while Parsons and associates have determined that functional outcome, as determined by the Constant score, is negatively correlated with joint space narrowing and glenoid degeneration. Other complications, such as prosthetic loosening, infection, and nerve injury are rarer, occurring at reported rates of 3% to 6%, 1% to 2%, and less than less than 1%, respectively.

The optimal timing of hemiarthroplasty treatment has also been evaluated. Acute reconstruction is technically easier and has been shown to be preferable to delayed hemiarthroplasty. Mighell found statistically significant improvement in ASES scores in patients treated within 2 weeks of initial injury, and Becker determined that fractures treated early with hemiarthroplasty showed better shoulder motion by video motion analysis and clinical outcomes when treated within 2 weeks of injury. In contrast, Prakash and coworkers did not find any difference in his series of early (less than 30 days) versus late (greater than 30 days, average time from injury to surgery was 13 months) treatment with...
hemiarthroplasty with regards to range of motion. While the optimal timing on hemiarthroplasty replacement remains controversial, it can be inferred from these studies that earlier surgery tends to lead to better outcomes.

**Reverse Total Shoulder Arthroplasty**

Concerns related to the positioning and healing of the tuberosity in hemiarthroplasty have led to the development and use of reverse shoulder arthroplasty (RSA) for the treatment of proximal humerus fractures, particularly in the elderly. By converting the glenoid into a spherical head and the head of the humerus into a socket, the center of rotation of the glenohumeral joint is medialized, giving the deltoid a more effective moment arm (Fig. 4). This new relationship eliminates the detrimental effect generated from rotator cuff deficiency resulting from tuberosity malunion or nonunion. Boileau and Cazeneuve evaluated the Grammont reverse shoulder prosthesis in traumatic cases and, although evaluating only a small series and reporting on early results, found this method to be acceptable.

Bufquin and colleagues evaluated the reverse total shoulder arthroplasty in 43 consecutive patients with a mean age of 78 years in a prospective review with short-term follow-up. Patients with three- or four-part fractures of the proximal humerus were treated with a RSA. Patients were found to have satisfactory clinical outcomes, with a mean anterior elevation of 97° and a mean active external rotation in abduction of 30°. The mean Constant scores, however, were only 44. Complications included reflex sympathetic dystrophy, neurologic injury (most of which resolved), and anterior dislocation. Despite these findings, the investigators proposed that RSA is an attractive alternative that still requires long-term investigation. A recent study by Cazeneuve and Cristofari evaluating radiographic outcomes at an average follow-up of 6.5 years demonstrated that, for acute proximal humeral fractures in the elderly, unsatisfactory radiographic images were obtained in 70% of cases. These unsatisfactory radiographic changes included evidence of glenoid loosening and scapular notching. However, only one revision was required at 12-year follow-up.

Levy and colleagues examined the use of RSA as a treatment for failed hemiarthroplasty for proximal humerus fractures. Over a five year period, 29 patients with a mean age of 69 previously treated with hemiarthroplasty were revised to a RSA (for glenoid arthritis or rotator cuff deficiency from tuberosity malpositioning). Proximal humeral allografts were used in cases where significant bone defects were encountered. After follow-up for an average of 35 months, the average total ASES score improved from 22.3 preoperatively to 52.1 (p < 0.001). There were also significant improvements noted in the ASES pain score, forward flexion, and abduction. There was a trend towards improvement in the ASES functional score, but it was not statistically significant. The overall complication rate, however, was 28%. The investigators concluded that the RSA offers a salvage-type solution to the problem of failed hemiarthroplasty due to glenoid arthritis, tuberosity and rotator cuff deficiency, and implant failure.

Currently, the role of RSA in primary and late salvage treatment of proximal humerus fractures is still being investigated. However, early evidence does show that it may have a role in primary treatment when tuberosity reconstruction is not a viable option or when salvage from a previously failed hemiarthroplasty is required.

**Conclusion**

Although no level one data exists, the literature suggests that three-part fractures are better treated with internal fixation with locking plates, especially those presenting with initial valgus displacement and those that possess a longer medial metaphyseal segment. Recommendations for most displaced three-part fractures include internal fixation, with the option of prosthetic replacement for those not amenable to humeral head preservation techniques. If surgical treatment is chosen, select four-part fractures in the elderly may be better treated with arthroplasty, with the exception of the valgus impacted four-part fractures. One must understand that the ability to re-establish adequate

---

**Figure 4 A.** Displaced four-part proximal humerus fracture in an 84-year-old patient, B, treated with reverse shoulder arthroplasty.
head-neck shaft angulation, anatomic reduction of the tu-
berosities, and obtain adequate post-operative rehabilita-
tion are vital to success and help determine optimal outcome
if this option is chosen. The role of reverse shoulder arthroplasty is currently being investigated, but may prove
to be another tool in the armamentarium in the treatment of
these complex injuries.

Regardless of implant technology, sound technique, accu-
rate anatomic reduction, and proper patient selection are the
most important factors in determining treatment success.
Therefore, the surgeon is not advised to use one treatment
option for all types of displaced proximal humerus fractures.
The various methods available at the surgeon’s disposal
serves as a spectrum of treatment options that, when used
appropriately, can maximize the outcomes of this difficult
clinical challenge.

Disclosure Statements
Drs. Min and Davidovitch have nothing to disclose. Dr. Tejwani or a member of his immediate family is a member of
a speakers’ bureau or has made paid presentations on behalf
of Stryker, Biomet, and Zimmer and has received research
or institutional support from Biomet. Dr. Tejwani is also a
product developer for the Biomet OptiLock Upper Extremitv
Plating System Proximal Humeral Plates.

References
1. Helmy N, Hintermann B. New trends in the treatment of prox-
imal humerus fractures. Clin Orthop Relat Res. 2006;442:100-
8.
bone in the femoral neck in elderly people: longitudinal find-
ings from the Dubbo osteoporosis epidemiology study. BMJ.
3. McLaurin TM. Proximal humerus fractures in the elderly are
we operating on too many? Bull Hosp Jt Dis. 2004;62(1-2):24-
32.
4. Court-Brown CM, Garg A, McQueen MM. The epidemi-
outcome after minimally displaced fractures of the proximal
6. Zyto K. Nonoperative treatment of comminuted fractures of
the proximal humerus in elderly patients. Injury. 1998;29-
5:349-52.
7. Court-Brown CM, Cattermole H, McQueen MM. Impacted
valgus fractures (B1.1) of the proximal humerus. The results
8. Ilchmann T, Ochsner PE, Wingstrand H, Jonsson K. Non-
operative treatment versus tension-band osteosynthesis in
three- and four-part proximal humeral fractures. A retropec-
tive study of 34 fractures from two different trauma centers.
9. Broxson S. Management of fractures of the humerus in Ancient
outcomes after nonoperative management of fractures of the
21.
following one-part proximal humeral fractures: a prospective
12. Court-Brown CM, McQueen MM. The impacted varus (A2.2)
proximal humeral fracture: prediction of outcome and results
13. Lill H, Bewer A, Korner J, et al. [Conservative treatment of
dislocated proximal humeral fractures]. Zentralbl Chir.
2001;126-3:205-10.
15. Lee CK, Hansen HR. Post-traumatic avascular necrosis of
the humeral head in displaced proximal humeral fractures. J
16. Neer CS 2nd. Displaced proximal humeral fractures. II. Treat-
ment of three-part and four-part displacement. J Bone Joint
labeling as a measure of humeral head viability after 3- or
18. Hintermann B, Trouillier HH, Schafer D. Rigid internal fixa-
tion of fractures of the proximal humerus in older patients. J
19. Gerber C, Schneeberger AG, Vinh TS. The arterial vasculariza-
tion of the humeral head. An anatomical study. J Bone Joint
20. Laing PG. The arterial supply of the adult humerus. J Bone
21. Naranja RJ, Jr., Iannotti JP. Displaced three- and four-part
proximal humeral fractures with an angular and sliding stable
fixation of three- and four-part fractures of the proximal
22. Hertel R, Hempfling A, Steihler M, Leunig M. Predictors of
humeral head ischemia after intracapsular fracture of the proximal
33.
23. Resch H, Povacz P, Frohlich R, Wambacher M. Percutane-
ous fixation of three- and four-part fractures of the proximal
fractures - current treatment options. Acta Chir Orthop Trau-
25. Rajasekhar C, Ray PS, Bhamra MS. Fixation of proximal
humeral fractures with a proximal humeral nail. J Shoulder Elbow
26. Mittlmeier TW, Stedtfeld HW, Ewert A, et al. Stabilization of
proximal humeral fractures with an angular and sliding stable