Full length article

Operative repair of proximal humerus fractures in septuagenarians and octogenarians: Does chronologic age matter?

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ABSTRACT

Background: With an expected doubling of the geriatric population within the next thirty years it is becoming increasingly important to determine who among the elderly population benefit from orthopaedic interventions. This study assesses post-operative outcomes in patients aged seventy or greater who sustained a proximal humerus fracture and were treated surgically as compared to a younger geriatric cohort to determine if there is a chronologic age after which post-operative outcomes significantly decline.

Methods: A retrospective chart review was conducted for 201 patients who sustained fractures of the proximal humerus (OTA 11A-C) and were treated operatively by open reduction and internal fixation. Data from 132 independent, active patients aged fifty-five or older was identified and analyzed. Forty-seven patients age 70 or older were compared to 78 patients aged 55–69. Average length of follow-up was 19.5 months. All complications were recorded. Univariate and multivariate analysis was conducted to assess for differences between groups.

Results: 95% of patients achieved fracture union within 6 months. No significant differences were found between cohorts with regard to gender, fracture severity, or CCI ($p=0.197$, $p=0.276$, $p=0.084$, respectively). Functional outcome scores, shoulder range of motion, and complications rates for patients aged 70 and older were not significantly different from patients aged 55–69. There were 10 complications in the older elderly cohort (21%), 6 of which required re-operation and 13 complications in the young elderly cohort (17%), 8 of which required re-operation.

Conclusions: Operative fracture repair using locked plating of the proximal humerus in septuagenarians and octogenarians can provide for excellent long-term outcomes in appropriately selected patients. These patients tend to have long term functional outcome scores, post-operative range of motion, and complication rates that are comparable to younger geriatric patients. Physicians should not exclude patients for repair of proximal humerus fractures based on chronological age cutoffs.

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1. Introduction

Debate continues regarding optimal treatment of proximal humerus fractures.^{1,2} This fracture occurs with an incidence of 105–342 per 100,000 persons per year.³ It is the third most common fracture type in patients older than sixty-five,⁴ and seventh most common fracture type overall.⁵

Systematic reviews have revealed that more data are needed to determine the ideal treatment of proximal humerus fractures.^{1,6} Many factors must be considered in this respect. Fracture characteristics, surgeon preference and skill, patient demand, patient expectations, and health all play a pivotal role in the management decisions shared by the orthopaedic surgeon and patient. While many orthopaedic surgeons may prefer surgical management in younger patients with displaced fractures of greater severity, a lack of consensus exists in older patients.⁷

This controversy is only heightened in the elderly, with poorer bone quality⁸ and increased risk for surgical intervention⁹ and complication. It has been shown that these fractures are more prevalent in fit, independent patients, who function at a moderate level despite advanced age.¹⁰ These elderly patients with osteoporotic proximal humeral fractures also tend to have an

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increased incidence of complex fractures as compared to a younger cohort.¹⁰ With increasing age, comorbid conditions may preclude intervention in many of these patients. With regard to treatment, non-operative management, operative reduction and internal fixation (ORIF) and arthroplasty have all been debated in the literature, with arguments for and against each, some particular to older patients.^{3,4,11,12}

We sought to determine if there is a chronological age after which the benefits of operative treatment for proximal humerus fractures decay. Towards this end we compared a cohort of patients aged seventy or greater to a younger elderly group aged fifty-five to sixty-nine, all treated operatively using a locking plate for proximal humerus fractures. Data was evaluated to determine if any significant differences existed with regards to time to union, functional outcomes, range of motion, and complication rates including re-operation.

2. Methods

Following institutional review board approval, a retrospective chart review was conducted for 199 patients with 201 displaced fractures of the proximal humerus (OTA 11a-c) treated operatively by fellowship trained trauma or shoulder surgeons with open reduction and internal fixation (ORIF). Data were collected from a prospective database consisting of patients presenting to one academic medical center between 2003 and 2015. Inclusion in the study required age of fifty-five or greater, acute non pathologic proximal humerus fracture, and treatment with ORIF using a locking proximal humerus plate and a minimum 6 months follow up. Data from 132 independent, active patients aged fifty-five or older was queried and 7 were excluded due to insufficient follow up leaving 125 eligible patients.

Operative decisions were made at the discretion of the treating surgeon based on clinical examination, imaging, and shared patient-physician treatment goals. The supervising surgeon for each case was one of 5 orthopaedic surgeons fellowship trained in shoulder or trauma. Operative fixation was performed using a deltopectoral approach, with suture fixation of displaced tuberosity fragments when present. A lateral cortical window was created to reduce the humeral head, and subsequently calcium phosphate cement or cancellous bone chips were used to fill the void. Once the tuberosities and proximal humerus head were reduced a locking plate was applied slightly laterally to the bicipital groove. The locking plate utilized was either a 90 mm plate (Synthes, Paoli, PA) or an 80 mm plate (Exactech, Gainesville, FL). Unicortical proximal locking screws were placed into the humeral head using an external guide. Placement was verified with the use of intraoperative fluoroscopy. The distal portion of the locking

plate was fixed to the humeral shaft using both locked and nonlocked bicortical screws, and braided sutures were tied down to the plate for final construct fixation.

All patients were seen at intervals of two, six, twelve, twenty-six, and fifty-two weeks for routine follow-up with their treating surgeon. Rehabilitation protocol was standardized beginning with isometric strengthening of the upper extremity on postoperative day one, including active range of motion of the hand, wrist, and elbow. Passive range of motion exercises of the shoulder were started one week postoperatively. Transition to active range of motion exercises occurred once radiographic evidence of healing was apparent at approximately six weeks postoperatively. Formal physical therapy was conducted beginning at six weeks postoperatively until maximal functional improvement was attained.

A trained interviewer obtained demographic, operative, and follow-up information at regularly scheduled intervals including three, six and twelve-month follow-up intervals, with additional follow-up as needed. The Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire was used to assess functional outcomes.¹³ Clinical assessments were made at each visit, along with radiographic assessments at six, twelve, twenty-six and fifty-two weeks. Range of motion evaluations for forward elevation and external rotation were assessed using a goniometer. Internal rotation was assessed by vertebral level of the ipsilateral thumb. All complications were recorded as they occurred.

Forty-seven patients age seventy or older with proximal humerus fractures were identified with a mean age of 78 ± 5 years. Average length of follow-up was 19 months with follow-up ranging from a minimum of 6 months to 63 months. These patients were compared to a cohort of 78 patients aged 55–69 with a mean age of 62 ± 3 years and average length of follow-up of 20 months with follow-up ranging from a minimum of 6 months to 72 months.

The septuagenarian and octogenarian cohort consisted of 37 females and 10 males, compared to 53 females and 25 males in the younger cohort ($p = 0.197$). No difference was found with respect to Charlson Comorbidity Index (CCI) in the septuagenarian and octogenarian cohort as compared to the younger cohort (CCI of 1.8 vs 1.1, respectively, $p = 0.084$). There was a non-significant difference between cohorts with regards to fracture classification according to the AO/OTA Classification (OTA 11A-C) ($p = 0.276$) and according to the Neer classification of proximal humerus fractures ($p = 0.115$) (Table 1).

The Wilcoxon-Mann-Whitney test was used for continuous variables and Pearson's chi-square test or Fischer exact test were conducted for categorical variables to assess for differences in demographic information including fracture severity and CCI, functional outcome scores, and range of motion, using SPSS Statistics 20 (IBM Corporation, Endicott, NY).

Table 1

Cohort Demographics. Study population including cohort comparisons for age, gender, fracture classifications, and Charlson Comorbidity Index.

Cohort Characteristics	Septuagenarian + Octogenarian Cohort	Young Geriatric Cohort	P value
Subjects included for data analysis	n = 47 (37F,10M) Mean age = 78 SD 5	n = 78 (53F,25M) Mean age = 62 SD 3	0.197 0.003
OTA fracture classification	11A (n = 11) 11B (n = 19) 11C (n = 17)	11A (n = 17) 11B (n = 37) 11C (n = 24)	0.276
Neer fracture classification	2 part (n = 12) 3 part (n = 27) 4 part (n = 8)	2 part (n = 17) 3 part (n = 43) 4 part (n = 18)	0.115
Charlson Comorbidity Index (CCI)	Mean = 1.8	Mean = 1.1	0.084

*Significance assigned to p -value < 0.05 .²⁹

3. Results

Ninety-five percent of patients achieved radiographic fracture union within 6 months. All fractures united by final follow-up. Mean shoulder range of motion at final follow-up for active forward elevation, active external rotation and internal rotation in the septuagenarian and octogenarian group was $136.5^\circ \pm 29^\circ$, $44.0^\circ \pm 16.9^\circ$, and vertebral level $L2 \pm 4$ levels. Mean shoulder range of motion at final follow-up for active forward elevation, active external rotation and internal rotation in the younger geriatric group was $142.2^\circ \pm 26.7^\circ$, $46.0^\circ \pm 18^\circ$, and vertebral level $T11 \pm 5$ levels, with no significant differences ($p=0.481$, $p=0.423$, $p=0.091$, respectively) (Table 2).

Mean DASH scores for patients aged 70 and older was 30.2 ± 18.1 , as compared to a DASH score of 24 ± 15.3 in the patients aged fifty-five to sixty-nine ($p=0.262$). There was no difference in complication rates with 10 complications occurring in the older cohort (21%), and 13 complications in the young elderly cohort (17%) ($p=0.644$). Complications included malreduction, screw penetration, fracture non-union, osteonecrosis, and infection. Six patients (12.8%) in the older cohort required reoperation as compared to 8 patients (10.3%) in the young elderly cohort ($p=0.524$).

4. Discussion

Proximal humerus fractures in the elderly represent an increasingly prevalent injury based on incidence trends and longevity. Emerging data on non-operative treatment has revitalized the debate as to optimal treatment of this common injury in the elderly.^{14,15} Largely, the data still remain equivocal, with limitations in ability to draw conclusions.¹⁶

A recent systematic review looked to identify outcomes in non-operative treatment of proximal humerus fractures. The authors concluded that non-operative treatment can lead to satisfactory outcomes with high rates of healing, even in patients with three- and four-part fractures. The authors also found functional range of motion to be within that necessary for

activities of daily living.¹⁷ However, they acknowledged the inherent biases introduced due to lack of standardized outcomes reporting.¹⁸ A recent meta-analysis has emphasized cautious interpretation of results arguing for equivalence in outcomes for operative versus non-operative fractures. Several important points regarding potential misinterpretations within the existing data include widely variant operative technique and skill, newer technological advents and careful examination of patient characteristics.¹⁹ Patient outcomes with regards to surgical repair of proximal humerus fractures using locked plating requires a skill based on a learning curve.^{20,21}

A recent randomized clinical trial comparing operative and non-operative treatment of displaced proximal humerus fractures concluded that no significant difference exists between treatment arms based on patient reported outcomes over 2 years.²² While this study appears robust regarding its outcomes data, it is one study, which should be regarded within the context of all available literature. It is important to stress that the results of our study indicate that significantly older patients can be treated operatively with good results, although assured, many of these patients sustain fractures that should be treated non-operatively due to the nature of their fracture or their overall state of health. Many factors must be considered in the decision making process, with patient independence and activity level crucial to the outcomes of these fractures which largely occur in an older, female population.²³

Previously our group demonstrated that elderly patients with proximal humerus fractures may be effectively treated using locked plating and provided rationale based on biomechanical evidence to corroborate the clinical results.²⁴ This current study indicates that a patient cohort consisting of patients aged seventy or older achieved outcomes consistent with patients who were on average, sixteen years younger. Despite complex fractures and relatively poorer bone quality known to be more prevalent in these older patients, surgical fracture fixation can provide for reliably good results in the hands of a skilled surgeon, with relatively low complication rates demonstrated here. The complications associated with operative repair of these fractures remain related to both patient as well as fracture characteristics. The wide range in

Table 2

Primary and Secondary Outcome Measures. Range of motion, functional outcome scores, complications and reoperation rates between cohorts.

Outcome Measures	Septuagenarian + Octogenarian Cohort	Young Geriatric Cohort	P value
Mean Range of Motion	• Active forward elevation (136.5° SD 24.5°)	• Active forward elevation (142.2° SD 27.1°)	0.481
	• Active external rotation (44.0° SD 14.4°)	• Active external rotation (46.0° SD 15.8°)	0.423
	• Active internal rotation (to L2)	• Active internal rotation (to T11)	0.091
Mean DASH Score	30.2	24	0.262
Complications	• Malreduction (n = 1)	• Malreduction (n = 1)	0.644
	• Screw penetration (n = 4)	• Screw penetration (n = 5)	
	• Nonunion (n = 1)	• Nonunion (n = 2)	
	• Avascular necrosis (n = 2)	• Avascular necrosis (n = 2)	
	• Infection (n = 2)	• Infection (n = 3)	
Reoperation Rate	6/47 (12.8%)	8/78 (10.3%)	0.521

DASH (Disabilities of the Arm, Shoulder, and Hand).

*Significance assigned to p -value <0.05 .²⁹

reported complication rates (9.7%–39.1%) across different studies reflects the multifaceted nature of injury patterns and surgical treatment of these fractures.^{25–28}

This study is a retrospective review with several inherent limitations. Treatment decisions were determined by the operative surgeon, and patients treated non-operatively or with alternative methods of operative reduction and internal fixation or arthroplasty were not included in this study. However, this study was never intended to compare different treatment methods between age groups. Functional outcomes scores in the study cohort were slightly worse than the comparison cohort at final follow-up, which were most likely attributable to differences in baseline functionality between groups, although baseline DASH scores were not obtained. The series presented here should be interpreted within the context of the specific patient characteristics exhibited.

In conclusion, this study demonstrates that carefully selected elderly patients with displaced proximal humerus fractures treated with a locking proximal humerus plate can achieve good to excellent functional outcomes, regardless of age. Complication and reoperation rates are contingent on a multitude of factors that can be optimized to provide for successful operative intervention. Despite the potential risks assumed with increasing chronological age, we found no manifestation of this in our results. Surgeons and patients can be reassured that age alone need not prohibit surgical intervention.

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References

- Handoll HH, Ollivere BJ, Rollins KE. Interventions for treating proximal humeral fractures in adults. *Cochrane Database Syst Rev*. 2012;12:CD000434.
- Bell JE, Leung BC, Spratt KF, et al. Trends and variation in incidence, surgical treatment, and repeat surgery of proximal humeral fractures in the elderly. *J Bone Joint Surg Am*. 2011;93(2):121–131.
- Burkhart KJ, Dietz SO, Bastian L, Thelen U, Hoffmann R, Müller LP. The treatment of proximal humeral fracture in adults. *Dtsch Arzteblatt Int*. 2013;110(35–36):591–597.
- Nho SJ, Brophy RH, Barker JU, Cornell CN, MacGillivray JD. Management of proximal humeral fractures based on current literature. *J Bone Joint Surg Am*. 2007;89(Suppl. 3):44–58.
- Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. *Injury*. 2006;37(8):691–697.
- Lanting B, MacDermid J, Drosdowech D, Faber KJ. Proximal humeral fractures: a systematic review of treatment modalities. *J Shoulder Elb Surg*. 2008;17(1):42–54.
- Guy P, Slobogean GP, McCormack RG. Treatment preferences for displaced three- and four-part proximal humerus fractures. *J Orthop Trauma*. 2010;24(4):250–254.
- Khmelnitskaya E, Lamont LE, Taylor SA, Lorich DG, Dines DM, Dines JS. Evaluation and management of proximal humerus fractures. *Adv Orthop*. 2012;2012:861598.
- De Kruijff M, Vroemen JP, De Leur K, Van Der Voort EA, Vos DI, Van Der Laan L. Proximal fractures of the humerus in patients older than 75 years of age: should we consider operative treatment? *J Orthop Traumatol*. 2014;15(2):111–115.
- Court-Brown CM, Garg A, McQueen MM. The epidemiology of proximal humeral fractures. *Acta Orthop Scand*. 2001;72(4):365–371.
- Gallinet D, Clappaz P, Garbuio P, Tropet Y, Obert L. Three or four parts complex proximal humerus fractures: hemiarthroplasty versus reverse prosthesis: a comparative study of 40 cases. *Orthop Traumatol Surg Res*. 2009;95:48–55.
- Thorsness R, Iannuzzi J, Noyes K, Kates S, Voloshin I. Open reduction and internal fixation versus hemiarthroplasty in the management of proximal humerus fractures. *Geriatr Orthop Surg Rehabil*. 2014;5(2):56–62.
- Ye T, Wang L, Zhuang C, Wang Y, Zhang W, Qiu S. Functional outcomes following locking plate fixation of complex proximal humeral fractures. *Orthopedics*. 2013;36(6):e715–e722.
- Hauschild O, Konrad G, Audige L, et al. Operative versus non-operative treatment for two-part surgical neck fractures of the proximal humerus. *Arch Orthop Trauma Surg*. 2013;133(10):1385–1393.
- Okike K, Lee OC, Mekanji H, Morgan JH, Harris MB, Vrahas MS. Comparison of locked plate fixation and nonoperative management for displaced proximal humerus fractures in elderly patients. *Am J Orthop*. 2015;44(4):106–112.
- Launonen AP, Lepola V, Flückilä T, Laitinen M, Paavola M, Malmivaara A. Treatment of proximal humerus fractures in the elderly. *Acta Orthop*. 2015;86(3):280–285.
- Namdari S, Yagnik G, Ebaugh DD, et al. Defining functional shoulder range of motion for activities of daily living. *J Shoulder Elb Surg*. 2012;21(9):1177–1183.
- Iyengar JJ, Devic Z, Sproul RC, Feeley BT. Nonoperative treatment of proximal humerus fractures: a systematic review. *J Orthop Trauma*. 2011;25:612–617.
- Jia Z, Li W, Qin Y, et al. Operative versus nonoperative treatment for complex proximal humeral fractures: a meta-analysis of randomized controlled trials. *Orthopedics*. 2014;37(6):e543–e551.
- Egol KA, Ong CC, Walsh M, Jazrawi LM, Teiwani NC, Zuckerman JD. Early complications in proximal humerus fractures (OTA Types 11) treated with locked plates. *J Orthop Trauma*. 2008;22(3):159–164.
- Aggarwal S, Bali K, Dhillon MS, Kumar V, Mootha AK. Displaced proximal humeral fractures: an Indian experience with locking plates. *J Orthop Surg Res*. 2010;5:60.
- Rangan A, Handoll H, Brealey S, et al. Surgical vs nonsurgical treatment of adults with displaced fractures of the proximal humerus. *JAMA*. 2015;313:1037.
- Jo MJ, Gardner MJ. Proximal humerus fractures. *Curr Rev Musculoskelet Med*. 2012;5(3):192–198.
- Shulman BS, Ong CC, Lee JH, Karia R, Zuckerman JD, Egol KA. Outcomes after fixation of proximal humerus (OTA Type 11) fractures in the elderly patients using modern techniques. *Geriatr Orthop Surg Rehabil*. 2013;4(1):21–25.
- Südkamp N, Bayer J, Hepp P, et al. Open reduction and internal fixation of proximal humeral fractures with use of the locking proximal humerus plate. Results of a prospective, multicenter, observational study. *J Bone Joint Surg Am*. 2009;91(805):1320–1328.
- Aksu N, Göğüş A, Kara AN, Işıklar ZU. Complications encountered in proximal humerus fractures treated with locking plate fixation. *Acta Orthop Traumatol Turc*. 2010;44(2):89–96.
- Faraj D, Kooistra BW, Vd Stappen WAH, Werre AJ. Results of 131 consecutive operated patients with a displaced proximal humerus fracture: an analysis with more than two years follow-up. *Eur J Orthop Surg Traumatol*. 2011;21(1):7–12.
- Hardeman F, Bollars P, Donnelly M, Bellemans J, Nijs S. Predictive factors for functional outcome and failure in angular stable osteosynthesis of the proximal humerus. *Injury*. 2012;43(2):153–158.
- Fisher RA. Nig J Paediatr. London: Oliver and Boyd. Statistical methods for research workers, 1950; p. 80.