

Functional Outcomes and Complication Analysis of Plate Osteosynthesis versus Hemiarthroplasty in Three-part and Four-part Proximal Humerus Fractures

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Abstract

Objective: To compare the functional results and complications of open reduction-internal fixation and hemiarthroplasty performed in Neer three-part and four-part proximal humerus fractures.

Methods: The retrospective study was conducted at the Istanbul Training and Research Hospital, Turkey, and comprised data of patients who were diagnosed with three-part or four-part fracture of the proximal humerus and underwent surgical procedure between January 2008 and April 2013. Those who had undergone open reduction-internal fixation using anatomical locking plates were placed in group A, and those who had undergone hemiarthroplasty were in group B. Constant-Murley shoulder outcome, University of California at Los Angeles shoulder and visual analogue scale scores were compared between the two groups. The degrees of forward flexion and abduction of the glenohumeral joint were recorded. Complications in both the groups were recorded. Data was analysed using SPSS 15.

Results: Of the 48 patients, 30(62.5%) were in group A; 16(53.3%) males and 14(46.7%) females, with an overall mean age of 60.0±9.4 years. The remaining 18(37.5%) were in group B; 7(39%) males and 11(61%) females, with an overall mean age of 67.3±10.1 years. The mean follow-up period was 18.7±16.4 months. The mean Constant-Murley and University of California at Los Angeles shoulder scores were not significantly different between the two groups ($p>0.05$). The mean visual analogue scale score was significantly higher in group A compared to group B ($p=0.021$). In group A, heterotopic ossification was observed in 1(3.4%) patient, avascular necrosis in 3(10%), screw penetration without avascular necrosis in 4(13.2%), and non-union in 1(3.4%), while in group B, shoulder subluxation was noted in 2(11.1%) patients and malunion of the greater tubercle in 6(33.3%).

Conclusion: Although statistically non-significant, higher functional scores, forward flexion and abduction degrees were observed in patients who had undergone open reduction-internal fixation, while significantly lower visual analogue scale scores were recorded in the hemiarthroplasty group.

Keywords: Proximal humeral fracture, Shoulder hemiarthroplasty, Locking compression plate, ORIF, Outcome measures.
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Introduction

Proximal humerus fractures are the third most common type of fractures in the elderly population, following hip and distal radius fractures, and are often associated with osteoporosis.¹ Approximately 80% of proximal humerus fractures exhibit no or minimal displacement, and can be treated conservatively. These fractures are considered Neer type 1 regardless of the fracture line. The Neer system divides the proximal humerus into four parts and considers not the fracture line, but the displacement as being significant in terms of classification. The four parts are the

humeral head, the greater tuberosity, the lesser tuberosity and the humeral shaft. Displacement is on a per-part basis. A fracture part is considered displaced if angulation exceeds 45 degrees, or if the fracture is displaced by more than 1 cm.² Even in Neer 3- and 4-part displaced fractures, surgical fixation did not prove to be superior to conservative treatment in terms of clinical results.³⁻⁵ In contrast, some studies have reported the superiority of surgical fixation over conservative treatment in terms of clinical outcomes in 3-part displaced proximal humerus fractures.⁶

Surgical treatment options include closed reduction and percutaneous pinning, osteosynthesis with anatomical plate and screw, osteosynthesis with intramedullary (IM) nail, partial shoulder prosthesis, and reverse shoulder prosthesis.

The reduction and maintenance of fractured fragments in closed reduction and percutaneous pinning and osteosynthesis with IM nails still pose a major problem and

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their application is very limited due to high malunion rates.^{7,8} While many studies have recommended plate osteosynthesis to protect the patients' bone stock, and to reduce the risk of erosion and osteoarthritis in the glenohumeral joint,⁶ others have recommended hemiarthroplasty, especially in patients who are predicted to have advanced osteoporosis and high risk of complications, such as osteonecrosis and implant failure after plate osteosynthesis.⁹ Despite the fact that it is more of a major surgical intervention, some studies have primarily advocated reverse shoulder prosthesis since it has functional results similar to that of open reduction-internal fixation (ORIF) and hemiarthroplasty, but requires revision less often.¹⁰ In a survey comprising 134 international orthopaedic surgeons, 37% preferred plate osteosynthesis, 29% preferred reverse shoulder arthroplasty, and 26% preferred hemiarthroplasty in 3-part and 4-part humerus fractures.¹¹

The current study was planned to compare the functional results and complications of ORIF and hemiarthroplasty performed in Neer three-part and four-part proximal humerus fractures.

Patients and Methods

The retrospective study was conducted at the Istanbul Training and Research Hospital, Turkey, and comprised data of patients who were diagnosed with Neer three-part or four-part fracture of the proximal humerus and underwent surgical procedure between January 2008 and April 2013. Data was retrieved after approval from the institutional ethics review committee, while the patients had given informed data-sharing consent at the last follow-up. Data was excluded for patients aged <50 year, those who had Neer 1-part and 2-part fractures, and those were lost to routine follow-up. Data was also excluded of patients who had an open fracture or any neurovascular injury.

In patients who underwent ORIF, reduction of the fracture was achieved with the help of temporary K-wires and stitches were done under fluoroscopy control. Tubercular fragments and rotator cuff tendons were fixed with stitches passed through the plate. No bone graft was used. In patients who underwent hemiarthroplasty, the head was removed and both the tubercles were prepared with tendinous parts. After cementless porous-coated shoulder prosthesis was applied, the bone graft that was removed from the fracture was placed between the upper end of the fracture and the prosthesis. Both tubercles were firmly attached to the prosthesis and humerus with sutures.

Patients were called for follow-up examinations, and anteroposterior and axillary radiographs, and true radiographs of the shoulder while the arm was in 30° of

external rotation were taken. In addition, a computed tomography (CT) scan was performed on all patients at the time of admission to assess fragmentation. Fractures were preoperatively evaluated according to the Neer classification. Constant-Murley shoulder outcome (CMSO), University of California at Los Angeles (UCLA) shoulder and visual analogue scale (VAS) scores were used to evaluate the functional status of the patients.^{12,13} The degrees of forward flexion and abduction of the glenohumeral joint were recorded. Radiologically, the extent of union was determined based on the callus tissue formation observed in direct radiographs in patients who underwent ORIF. The patients were radiologically monitored to assess whether the fixation was inadequate or whether screw penetration developed. In patients who underwent hemiarthroplasty, the position of the prosthesis, presence of the radiolucent line around the prosthesis, the status of the glenoid, the presence of heterotopic bone formation, union of the greater and lesser tubercles, and bone stock were evaluated.

Data was analysed using SPSS 15. Descriptive statistics were presented as frequencies and percentages for categorical variables and as mean and standard deviation for numerical variables. In cases where the numerical variables exhibited normal distribution, comparisons between two groups were done using student's t test, and Mann-Whitney U test when they did not exhibit normal distribution. In comparison of more than two groups, one-way analysis of variance (ANOVA) and Kruskal-Wallis tests were utilised. Subgroup analyses of multiple groups were performed using Tukey's test when data was normally distributed. The differences of categorical variables between groups were tested using chi-square analysis. In situations where conditions were not met, Monte Carlo simulation was performed. Relationships between numerical variables were evaluated using Spearman's correlation analysis. The significance level was set at $p < 0.05$.

Results

Of the 48 patients, 30(62.5%) were in group A; 16(53.3%) males and 14(46.7%) females, with an overall mean age of 60.0 ± 9.4 years (range: 50 to 87 years). The remaining 18(37.5%) were in group B; 7(39%) males and 11(61%) females, with an overall mean age of 67.3 ± 10.1 years (range: 57 to 83 years). The mean age of group B was significantly higher than group A ($p = 0.008$). The mean time to surgery was 9.3 ± 10.0 days (range: 1-45 days) following the trauma. The mean time to surgery in group B was significantly higher than group A ($p = 0.008$). The mean length of hospital stay was 10.2 ± 4.8 days (range: 2-22 days), while the average follow-up period was 18.7 ± 16.4 months (range: 5-53 months). There was no significant difference

between the groups in terms of follow-up time ($p=0.488$). The cause of fractures was a fall in 38(79.2%) patients, non-traffic accident 5(10.4%), road traffic accident (RTA) 2(4.2%), electrocution 2(4.2%), and occupational accident 1(2%).

Table-1: Comparison of the demographic and functional results of the patients who underwent plate osteosynthesis and hemiarthroplasty.

	ORIF (n=30)	Hemiarthroplasty (n=18)	p-value
Age (mean±SD) (years)	60.0±9.4	67.3±10.1	0.008
Gender n (%)			
Male	16 (53.3)	7 (38.9)	0.332
Female	14 (46.7)	11 (61.1)	
Side n (%)			
Right	14 (46.7)	8 (44.4)	0.881
Left	16 (53.3)	10 (55.6)	
Classification n (%)			
Neer three-part	18 (60.0)	5 (27.8)	0.094
Neer four-part	5 (16.7)	6 (33.3)	
Fracture-dislocation	7 (23.3)	7 (38.9)	
Time to surgery (days) (mean±SD)	8.5±6.5	16.6±12.1	0.008
Follow-up time (months) (mean±SD)	18.3±10.2	18.7±16.4	0.488
Constant-Murley score (mean±SD)	66.8±17.6	59.1±17.8	0.147
UCLA shoulder score (mean±SD)	26.1±4.4	24.9±4.1	0.362
VAS score (mean±SD)	2.5±1.8	1.9±1.9	0.021
Forward flexion angle (mean±SD)	88.3±41.1	63.9±45.4	0.061
Abduction angle (mean±SD)	80.2±33.1	65.6±39.0	0.086
Complications			
Avascular necrosis	3 (10.0)	-	0.001
Heterotrophic ossification	1 (3.3)	-	
Nonunion	1 (3.3)	-	
Subluxation	-	2 (11.1)	
Malunion of the greater tubercle	-	6 (33.3)	
Screw penetration	4 (13.3)	-	

ORIF: Open reduction-internal fixation, SD: Standard deviation, UCLA: University of California at Los Angeles.

Table-2: Relationship of functional outcome pain with age and time to surgery.

	Age		Time to surgery	
	r	p-value	r	p-value
Constant-Murley score	-0.406	0.004	-0.408	0.004
UCLA shoulder score	-0.260	0.074	-0.358	0.012
VAS score	-0.169	0.250	0.082	0.581
Forward flexion angle	-0.391	0.006	-0.365	0.011
Abduction angle	-0.375	0.009	-0.388	0.006

UCLA: University of California at Los Angeles, VAS: Visual analogue scale.

Table-3: Relationship of functional outcome pain with fracture type.

	Neer 3-part (n=23)	Neer 4-part (n=11)	Fracture-dislocation (n=14)	p-value
Constant-Murley score (Mean±SD)	66.2±16.5	53.9±21.2	68.1±15.4	0.100
UCLA shoulder score (Mean±SD)	26.8±3.3	22.3±5.1	26.3±3.9	0.009
VAS score (Mean±SD)	2.2±1.7	2.5±2.4	2.3±1.5	0.949
Forward flexion angle (Mean±SD)	86.5±33.4	65.5±48.0	77.9±55.4	0.431
Abduction angle (Mean±SD)	78.7±26.2	61.8±36.8	78.2±47.3	0.233

SD: Standard deviation, UCLA: University of California at Los Angeles, VAS: visual analogue scale.

Besides, 23(48%) patients had fracture Neer 3-part, 11(23%) Neer 4-part and 14(29%) had fracture-dislocation. Of the total, 12(25%) patients were classified as American Society of Anesthesiologists (ASA) grade 3, 18(38%) as ASA-2 and 18(38%) as ASA-1.

The mean CMSO and UCLA shoulder scores were not significantly different between the two groups ($p>0.05$). The mean VAS score was significantly higher in group A compared to group B ($p=0.021$). The mean degree of forward flexion was higher in group A compared to group B, but the difference was statistically non-significant ($p=0.061$).

In group A, heterotrophic ossification was observed in 1(3.4%) patient, avascular necrosis in 3(10%), screw penetration without avascular necrosis in 4(13.2%), and non-union in 1(3.4%). No implant failure was observed in any of the direct radiographic examinations during the follow-up period. In group B, shoulder subluxation was noted in 2(11.1%) patients. Despite the poor functional status of their shoulders, these patients did not accept to undergo revision surgery as they did not feel serious pain. Malunion of the greater tubercle was noted in 6(33.3%) patients in group B (Table 1).

CMSO and UCLA shoulder scores, degree of forward flexion and the abduction degree exhibited a significant negative relationship with time-to-surgery ($p<0.05$) (Table 2). Mean UCLA shoulder score in Neer three-part and four-part fracture groups were significantly different ($p=0.009$). The mean UCLA shoulder score in Neer four-part was significantly lower than those of Neer three-part and fracture-dislocation groups ($p<0.05$) (Table 3).

Discussion

The most important finding of this study is that, although statistically non-significant, higher functional scores, forward flexion and abduction degrees were observed in the ORIF group, while significantly lower VAS scores were recorded in the hemiarthroplasty group. In terms of complications, screw penetration, avascular necrosis, heterotrophic ossification and non-union were observed in patients who underwent ORIF. Patients who underwent hemiarthroplasty developed shoulder subluxation and malunion of the greater tubercle.

In the current study, the mean age of the patients who underwent hemiarthroplasty was significantly higher than those who underwent ORIF, which is in accordance with literature.¹⁴ As the age of the patient increases, the amount of osteoporosis increases and the bone quality decreases, leading the surgeons to perform hemiarthroplasty. The

current study also demonstrated that functional scores, forward flexion and abduction degrees decreased significantly as age and preoperative waiting time increased. This situation may be associated with an increased risk of osteonecrosis and screw penetration if ORIF is to be preferred, or an increased risk of malunion and non-union after tuberculoplasty if hemiarthroplasty is to be preferred in advanced age since the bone quality decreases. In a recent study, there was no significant difference in terms of functional outcome between patients over and under 70 years of age who underwent ORIF with allografting, if the medial cortex fracture was comminuted or the metaphyseal-diaphyseal defect was >2cm.¹⁵ It can be concluded that anatomical reduction and reconstruction are more important factors than age in terms of functional results.

Three-part and four-part fractures are considered unstable, and surgical treatment is recommended. However, functional results of hemiarthroplasty performed following an unsuccessful conservative treatment have been shown to be worse than early hemiarthroplasty.¹⁶ In the current study, the functional results got worse as the preoperative waiting time increased in both hemiarthroplasty and ORIF groups.

Clinical results after ORIF have been shown to be better than hemiarthroplasty in three-part and four-part proximal humerus fractures.^{17,18} Techniques such as fibular allograft support or augmenting the screws with cement have been developed to reduce the risk of osteonecrosis and screw penetration in the performance of ORIF, and better radiological results have been reported.^{17,19} However, difficulties in obtaining fibular allografts and problems such as penetration of the cement in the glenohumeral joint restricted the routine use of these techniques. Although the deltopectoral approach is used in the ORIF technique, as was the case in the current study, deltoid-split approach may also be preferred.²⁰ In a recent meta-analysis, fewer occurrences of humeral head osteonecrosis and shorter surgery were reported with the deltoid-split approach compared to the deltopectoral approach.²¹

In accordance with literature, the current study obtained significantly lower VAS scores in patients who underwent hemiarthroplasty compared to those who underwent ORIF.^{22,23} Despite the lower functional scores, forward flexion and abduction degrees compared to the ORIF patients, the patients in the hemiarthroplasty group felt satisfied since they had less pain, to the extent that two of them refused to undergo re-surgery although they had subluxation. It has been shown that for hemiarthroplasty to prove successful in reducing pain and in achieving successful functional results, tuberculoplasty should be

properly performed and the rotator cuff should be intact.^{22,24} In the current study, six of the 18 patients who underwent hemiarthroplasty developed malunion of the greater tubercle and this negatively affected the functional outcomes.

The current study has limitations in terms of small sample size and short follow-up period.

Conclusion

Although statistically non-significant, higher functional scores, forward flexion and abduction degrees were observed in ORIF patients, while significantly lower VAS scores were recorded in hemiarthroplasty patients with three-part and four-part fractures of the proximal humerus. When evaluated in terms of complications, osteonecrosis of the humeral head and screw penetration in ORIF, and malunion or non-union of the tubercles in hemiarthroplasty were noted.

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