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An evaluation of functional outcome following surgical management of fractures of the proximal humerus with Neer's scoring system

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ABSTRACT

Background: Fractures of the proximal humerus are complex injuries associated with significant morbidity. Various options are available for management including non-operative treatment, depending upon the pattern of the fracture, quality of the bone and the surgeon's familiarity with the techniques. The age of the patient, physical activity and the medical fitness also largely influence the treatment options. The aim of this study was to evaluate the functional outcome following surgical management of these fractures and to compare the results with studies as available in literature.
Methods: 30 patients with fractures of the proximal humerus managed by surgical means were studied from January 2012 to January 2014 and were followed up for a minimum period of two years.
Results: All the fractures treated united clinically by 8 weeks and radiologically by 16 weeks. There were no cases of delayed or non-union in our series. The fractures were more common in men with a gender distribution of 1.3:1 and were also more common in the age group of 50 to 65 years (53%). As per the Neer's scoring system, 60% patients had excellent results while 33% patients had satisfactory results. They were all pain free and successfully returned to their pre-injury work. 6% patients had an unsatisfactory result.
Conclusions: Surgical management of proximal humerus fractures following the principles of articular surface reconstruction, restoration of the anatomy, stable fixation, with minimal injury to the soft tissues and early mobilization, gives good functional results.

Keywords: Proximal humerus, Fractures, Fixation, Neers scoring

INTRODUCTION

Proximal humeral fractures are the second most common upper-extremity fractures and the third most common fracture after hip fractures and distal radial fractures, in patients who are older than sixty-five years of age. They account for about 5% of all injuries to the appendicular skeleton.[1] Despite recent advances in imaging and fixation techniques, the treatment of displaced fractures affecting the proximal humerus remains a challenge. Many such fractures occur in elderly patients who may have poor general health, bone quality, and postoperative compliance. The remainder tend to occur in younger patients with better bone quality who have experienced high-energy trauma that is usually associated with severe soft- tissue injuries. Specifically, the labrum, capsule, rotator cuff, brachial plexus, peripheral nerves, and blood vessels can all be injured in cases of high-energy trauma. As with the treatment of almost any fracture, the goal remains to obtain and maintain an acceptable reduction while healing progresses. Although this goal often can be achieved with limited internal fixation and a period of prolonged immobilization, the subsequent stiffness can be quite disabling. Optimal treatment involves providing

fixation that will withstand the stress of early passive movement, an ideal that cannot always be attained. Osteosynthesis may be followed by osteonecrosis, malunion, and soft tissue damage with reduced postoperative mobility.[2,3] The preferred treatment varies depend on the patient's age and bone quality, the expertise of the surgical team and the patients expectation. Although a number of reports have described the outcome of treatment of proximal humeral fractures, comparison of these fractures is hampered by inconsistancy in fracture classification, treatment and evaluation methods. The aim of this study was to evaluate the functional outcome following surgical management of these fractures and to compare the results with studies as available in literature.

METHODS

30 patients with fractures of the proximal humerus managed by surgical means were included in our study. This was a prospective study conducted at Saveetha Medical College and hospital from January 2012 to January 2014. All 30 patients with fractures of the proximal humerus with Neer's classification grade 2 to grade 4 who were willing for surgery were included in our study while medically unfit patients, pathological fractures, fractures in the pediatric age group, shaft of humerus fractures with proximal extension and Neer's one part fracture were excluded from our study. On admission of the patient a careful history was elicited from the patients and/or attendants of injury and the severity of trauma. The patients were then assessed clinically to evaluate their general condition and the local injury. The general condition of the patient and the vital signs were recorded. The local examination of injured shoulder was done for swelling, deformity, loss of function and altered attitude. Any nerve injury was also looked for and noted. Axillary nerve was assessed by looking for anaesthetic patch over lateral aspect of shoulder.

Radiographs of the proximal humerus-antero-posterior view, scapular Y view and Axillary views were taken and fractures were classified according to Neer's classification. In a few cases of three and four part fractures CT scan was taken to get a better understanding of the fracture configuration and to plan for surgery. Next the limb was immobilized in U slab and arm-pouch. The patient was taken for surgery after routine investigations and after obtaining physician and anaesthetic fitness towards surgery The consent for surgery was also taken from the patient and attendants after explaining the procedure and possible complications. Following factors were taken into consideration while deciding the modality of treatment to be used such as fracture classification, presence of humeral head dislocation and humeral head comminution, valgus impaction, fracture comminution, quality of bone, age of the patient, associated general and medical condition of the patient, other associated lesions e.g. brachial plexus palsy and functional requirements of the patient.

All patients were treated by one of the following methods.

- Closed reduction and percutaneous K- wires fixation.
- Open reduction and internal fixation with locking compression plate.

Indications for closed reduction and percutaneous fixation

1. Un-displaced two, three or four part fractures defined as <45 degree of angulation of articular surface or less than 1 cm of displacement between major fragments.
2. Where the fracture can be reduced by closed reduction and is stable.
3. Maintenance of glenohumeral congruity.
4. Poor general or medical condition of the patient especially elderly where a short procedure is required.
5. Two, three and four part valgus impacted fractures without lateral displacement.

Indications for open reduction and internal fixation:

1. Young age
2. Absence of comminution of head (intact humeral head).
3. Good bone quality.
4. Displaced fractures with angulation of the articular surface of more than 45 degrees.
5. Displacement between the major fragments of more than 1cm.

Patients underwent surgery under general anaesthesia/ brachial plexus block. In simple two part fractures, especially in elderly patients with poor bone stock, closed reduction was done under fluoroscopic guidance and fixed with two to three K wires. In the cases of two, three and four part fractures with significant communition and displacement, ORIF was done. The proximal humerus was exposed through a standard deltopectoral approach and the fracture was provisionally fixed with k wires and then definitive fixation was done with a proximal humerus locking compression plate with plate positioned at least 5 mm distal to the upper end of the greater tuberosity and at least 2 mm posterior to the bicipital groove thus sparing the tendon of long head of biceps. Then with maintenance of prior achieved reduction, multidirectional screws were used to fix proximal fragments. Rotator cuff, capsule and subscapularis muscle tears/avulsions were repaired meticulously. Tuberosities, whenever found fractured, were fixed to the plate applying tension band principle and using non absorbable sutures. The decision regarding the use of locking or the cortical screws for plate fixation to the

humeral shaft was left to the discretion of the operating surgeon with locking screws being preferred for the older patients with suspected osteoporotic bones.

Table 1: Neers functioning grading.

Functional assessments	Points
Pain	
None/ignores	35
Slight, occasional, no compromise in activity	30
Mild, no effect on ordinary activity	25
Moderate, tolerable, makes concessions, uses aspirin	15
Marked, serious limitations	5
Totally disabled	0
Function	30
Strength	
Normal	10
Good	8
Fair	6
Poor	4
Trace	2
Zero	0
Reaching	
Top of head	2
mouth	2
Belt buckle	2
Opposite axilla	2
Brassiere hook	2
Stability	
lifting	2
throwing	2
pounding	2
pushing	2
Hold overhead	2
Range of motion	
Flexion (sagittal plane)	
180^0	6
170^0	5
130^0	4
100^0	3
80^0	2
$<80^o$	1
Abduction (coronal plane)	
180^0	6
170^o	5
140^0	4
100^o	3
80^0	2
$<80^0$	1
Extension	
45^0	3
30^0	2
15^0	1
$<15^0$	0
External rotation [1]	
60^0	5
30^0	3
10^0	1
$<10^0$	0
Internal rotation [1]	
90^0 (T-6)	5
70^0 (T-12)	4
50^0 (L 1-5)	3
30^0 (gluteal)	2
$<30^0$	0
Anatomy [2]	
None	10
Mild	8
Moderate	4
Marked	0-2
Results	
Excellent	90-100 points
Satisfactory	80-89 points
Unsatisfactory	70-79 points
Failure	<70 points

[1] From anatomical position with elbow bent

[2] Rotation, angulation, joint incongruity, retracted tuberosities, metal failure, myositis, non-union, avascular necrosis.

The basic surgical principles followed were good anatomical reduction of the fracture with stable internal fixation while keeping the soft tissue dissection to the minimum in order to preserve the vascularity of the bone. After fixation, the shoulder was put through its range of movements and the stability of the fixation was checked and found to be satisfactory, thorough wound wash was given and closure was done in layers. All patients were immobilized in a broad arm sling and appropriate antibiotics and analgesics were given. Immediate postoperative radiographs were taken to determine the bone alignment and maintenance of reduction. The first wound inspection was on the 3rd postoperative day and then at 3 day intervals. Suture removal was done on the 12th postoperative day. Passive range of motion and pendulum exercises was begun immediately depending on the pain tolerance and compliance of the patient. K-wires were removed at about 6-8 weeks. The active range of motion were started at 1-2 weeks postoperatively, depending on stability of the fixation and quality of the bone. The sling was discontinued by 1 to 2 weeks depending upon fracture stability. Following discharge clinical and radiological evaluations were done at 6 weeks and at 3, 6, 9, 12 and 24 months. Functional assessment was done using Neer's functional scoring system and all the findings were documented accordingly (Table 1). The data collected was analyzed using IBM SPSS Version 22.0. Armonk, NY: IBM Corp. Continuous variables were expressed as mean±SD and categorical variables were expressed as number and percentages. Chi square test was used in the comparison of categorical variables. A P value of less than 0.05 was considered to be statistically significant.

RESULTS

30 patients with fractures of the proximal humerus managed by surgical means were studied from January 2012 to January 2014. Age of the patients ranged from 20 to 65 years with the mean age being 49.1 years. Proximal humerus fractures were found to have a higher incidence in the 50 to 65 age group (table 2).

Table 2: Age incidence.

S. No	Age (years)	Number of patients	Percentage (%)
1	20-30	2	6.6
2	31-40	6	20
3	41-50	6	20
4	51-60	8	26.6
5	>60	8	26.6

Table 3: Mode of injury.

S. No	Mode of injury	Number of patients	Percentage (%)
1	Slip and fall	17	56.6
2	Road traffic accident	13	43.4

Table 4: Associated injuries.

S. No	Associated fractures	Number of patients
1	Clavicle	2
2	Shaft of femur	1
3	Tibial shaft	3
4	Distal radius	1

Table 5: Time of presentation to the hospital.

S. No	Time of presentation (hours)	Number of patients	Percentage (%)
1	<24	12	40
2	24-48	8	26.6
3	48-72	8	26.6
4	>72	2	6.6

Out of 30 cases there were 17 males (57%) and 13 females (43%). Males predominated over females in our study with the ratio of males to females being 1.3:1 (Figure 1). Right side fractures were more commonly seen with 18 patients having fractures of the right proximal humerus (Figure 2). Most of the fractures in the older age group were caused by a simple slip and fall while road traffic accidents were the common mode of injury in the younger age group (Table 3). Associated injuries were seen in 7 patients which were managed accordingly (Table 4) Majority of the injuries were closed fractures while there were 3 cases of Gustilo and Anderson grade 1 compound fractures. Most of the patients in our study presented to the hospital within 24 hours of injury while two cases presented after 72 hours (Table 5). The reason for the late presentation was delay in case referral from another center and one patient had initially opted for native treatment and then reported later to the hospital for further management. Most of the patients were operated within 1 to 3 days of presentation to the hospital while 2 patients were operated within 24 hours (Table 6). The fractures were classified according to Neer's classification with two part fractures being the most common type accounting for 60% of cases followed by three part fractures (Table 7). The fractures were fixed with percutaneous pinning in 11 cases and open reduction and internal fixation with proximal humerus locking compression plate in 19 cases (Table 8). The average period of stay in the hospital was 9 days ranging from 8 to 14 days. The average surgical time was 62±5 minutes. The mean time to radiological time to callus formation was 10 weeks ranging from 8 to 14 weeks. 70% of the patients had radiological evidence of callus formation by 8 weeks and all of them had evidence at the end of 6 months. The mean time to achieve clinical and radiological union was 16 weeks with a range from 12 to 21 weeks. There were no cases of delayed or nonunion noted in our series and no cases of implant failure. In our series 4 patients had adhesive capsulitis while 2 patients had varus malunions which resulted in decrease in the range of shoulder movements. Superficial wound infection and pin track infection was seen in one case each while there were no cases with deep infection. There were no cases with screw back out, implant failure or avascular necrosis (Table 9).

Table 6: Time from presentation to surgery.

S. No	Time frame	Number of patients	Percentage (%)
1	<24 hours	2	6.6
2	1-3 days	17	56.6
3	3-5 days	8	26.6
4	>5 days	3	10

Table 7: Fractures according to Neers classification.

S. No	Neer's classification	Number of patients	Percentage (%)
1	2 part	18	60
2	3 part	7	23.3
3	4 part	5	16.7

Table 8: Methods of fixation employed.

S. No	Method of fixation	Number of patients	Percentage (%)
1	Closed reduction with k wire fixation	11	36.6
2	ORIF with locking compression plates	19	63.4

Based on Neer's functional scoring system, 18 patients had an excellent result while satisfactory results were seen in 10 patients and 2 patients had an unsatisfactory result (Table 10). The limitations of our study could possibly be a relatively small sample of patients and a short period of follow up.

Table 9: Complications

S. No	Complications	Number of patients
1	Adhesive capsulitis	4
2	Varus malunion	2
3	Delayed union	0
4	Nonunion	0
5	Superficial infection	1
6	Pin tract infection	1
7	Screw backout	0
8	Avascular necrosis	0

Table 10: Results as per Neers grading.

S. No	Neers grading	Number of patients	Percentage (%)
1	Excellent	10	60
2	Satisfactory	18	34
3	Unsatisfactory	2	6

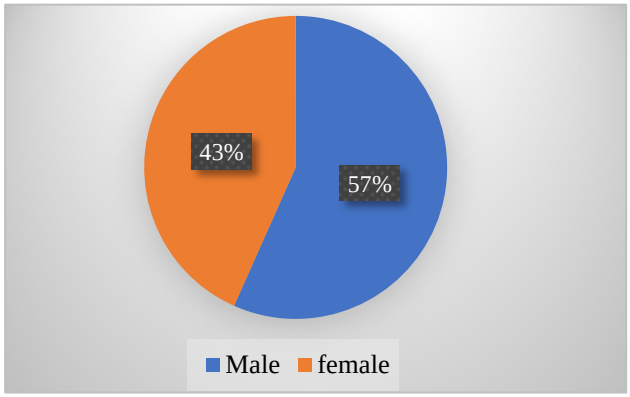

Figure 1: Sex incidence.

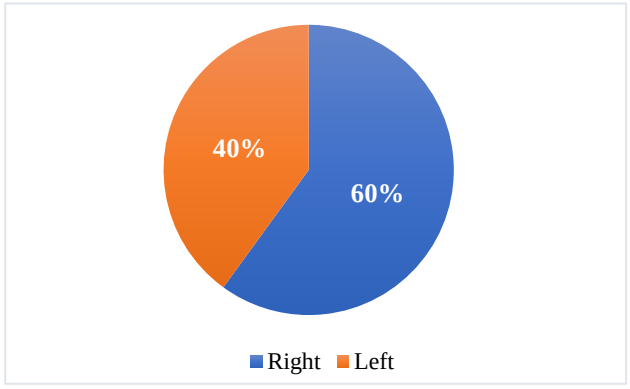

Figure 2: Side dominance.

DISCUSSION

Proximal humeral fractures are the second most common upper-extremity fractures and the third most common fracture after hip fractures and distal radial fractures, in patients who are older than sixty-five years of age. Despite recent advances in imaging and fixation techniques, the treatment of displaced fractures affecting the proximal humerus remains a challenge. Many such fractures occur in elderly patients who may have poor general health, bone quality, and postoperative compliance. An anatomical reduction and good rehabilitation is a strong predictor for good functional outcome.[4]

In the past these fractures were treated conservatively by prolonged immobilization which often resulted in considerable morbidity in the form of shoulder stiffness.[5] But in recent times with the increased knowledge regarding the anatomy of the region, better understanding of biomechanics and more choice of implants available for fixation ,there has been an shift towards surgical management of these fractures with options such as percutaneous pinning, open reduction and internal fixation with locking plates and hemiarthroplasty.[6-9]

Percutaneous pinning is a minimally invasive technique with limited indications. Amenable fracture patterns include 2-part proximal humerus fractures, ideally of the surgical neck, and 3- or 4-part fractures with adequate bone stock.[10] Theoretically, this technique limits iatrogenic vascular compromise, postoperative pain, operative time, and blood loss while improving cosmesis. Good outcomes can be achieved 70% of the time in 2-part fracture patterns.[11] Comparison of percutaneous techniques in all fracture patterns revealed, as one may expect, that 4-part fractures had the poorest results.[12] Better outcomes are reported using percutaneous fixation in patients with good bone quality, an intact medial calcar, lack of proximal shaft comminution, and stable fixation under dynamic fluoroscopy.[13] Reported complications of this technique include pin track infections, avascular necrosis of the humeral head, and pin migration with resultant loss of reduction. Longer term follow up of patients treated with percutaneous fixation revealed greater prevalence of osteonecrosis and post traumatic osteoarthritis than previously reported.[14]

Osteosynthesis is indicated for 2-, 3-, and 4- part fractures in appropriate patients. Exceptions include some 4-part fractures, head-splitting fractures, and fracture-dislocations, which are indicated for prosthetic replacement. While plate fixation has been shown to have superior patient outcome scores when compared with non-operative treatment in elderly patients, a recent randomized controlled trial showed better radiographic outcomes for plate fixation but equivalent functional outcomes in three- and four-part fractures.[15,16] Classically, indications for fixation in 4- part fractures include valgus impaction with preservation of the medial

capsular blood supply.[17] In our experience, however, more complex 4-part patterns can successfully be treated with ORIF. Complications with osteosynthesis, however, remain high. Particularly in patients with osteoporotic bone, high rates of intraarticular screw penetration have been reported.[18] This can lead to subsequent impingement from plate migration, nonunion, malunion, or intraarticular penetration of screws.[19-21] The risk of avascular necrosis (AVN) secondary to vascular compromise is greater in more complex fracture patterns and may be compounded by iatrogenic soft tissue stripping. While this concern still exists, the correlation between head perfusion and development of ischemia is more complex than initially thought. Hertel et al initially observed that predictors of humeral head ischemia as based on intraosseous laser Doppler flowmetry were metaphyseal head extension, integrity of medial hinge, and basic fracture pattern.[22] These patients were followed long term, and it was found that in fractures demonstrating intraoperative ischemia, 8/10 did not go on to humeral head collapse from AVN, and the other 2/10 demonstrated collapse at mean 5 year follow up. In those fractures without intraoperative ischemia, 4/30 still went on to humeral head collapse from AVN. Clearly, humeral head ischemia is not the only factor leading to AVN in proximal humerus fracture as most fractures with intraoperative ischemia did not go on to collapse.[23]

In our study of 30 cases of proximal humerus fractures treated by surgical means we observed that these fractures have a bimodal age distribution with simple falls contributing to fractures in the elderly population while road traffic accidents were the most common mode of injury in younger individuals. Most studies as available in literature also report similar findings.[2] In a study of Darder, 35 patients with displaced 4 part fractures were managed with K wire fixation and the findings in their study were an excellent outcome in 36% of the patients. They recommended K wire fixation in the elderly population due to the osteoporotic quality of the bone.[24]

Lill et al studied a series of 35 patients who were managed by open reduction and internal fixation with locking compression plates and they reported the best results were seen in two part fractures which was similar to what was observed in our study as well.[9] Esser et al studied 26 cases of fractures of the proximal humerus and they concluded that 84.6% of cases had an excellent result following open reduction and internal fixation.[25] Wijgman et al studied 60 patients with proximal humerus fractures and reported that 87% of cases had a good to excellent result.[26] Paavolainen et al studied 41 patients in their series and they concluded that displaced fractures of the proximal humerus treated with open reduction and internal fixation gave good results in 74% of cases.[27] In our study based on Neer's functional scoring system, 18 patients had an excellent result while satisfactory results were seen in 10 patients and 2 patients had a poor result which was comparable with that of other studies. The results of surgical management were better in Neer's 2 part fractures as compared to 3 and 4 part fractures. Unsatisfactory outcomes were seen in the 4 part fractures as was expected.

In our series, we had complications like adhesive capsulitis in 4 cases with varus collapse in 2 patients and one case each of superficial skin infection and pin track infection. There were no delayed or nonunions noted and no cases of screw backout or avascular necrosis. The patients with adhesive capsulitis were started on physiotherapy and shoulder mobilization and were found to be faring well at a later follow up. The fractures with varus collapse were due to difficulty in reduction intra operatively due to communition and poor bone stock. They eventually went in for union with decrease in range of movements of the shoulder clinically. The two cases with superficial and pin tract infections were treated with antibiotics and both responded well to treatment. All the fractures united well at the end of 6 months and all patients were followed up regularly for a minimum period of two years. None of the patients in our series were lost to follow up.

CONCLUSION

By this study, we conclude that surgical management of proximal humerus fractures uniformly leads to a satisfactory functional outcome over a short term follow up in most of the patients. The results are better in Neer's type 2 fractures as compared to types 3 and 4. A varus malalignment leads to an unsatisfactory functional outcome and should be avoided if possible. The surgery carries a steep learning curve and various complications could be associated with it. However, proper use of locking plate principles and meticulous soft tissue handling with aggressive postoperative rehabilitation go a long way in ensuring a satisfactory functional outcome.

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REFERENCES

1. Court Brown CM, Caesar B. Epidemiology of adult fractures: A review. Injury. 2006;37:691-7.
2. Klein M, Ostermann PAW, Juschka M, Hinkenjann B, Scherger B. Treatment of comminuted fractures of proximal humerus with Delta III reverse prosthesis. J Orthop Trauma. 2008;22:698–704.
3. Okcu G, Aktuglu K. Management of proximal humerus fractures with intramedullary flexible nails. Osteo Trauma Care. 2003;11:52-5.
4. Jobe FW, Tibone JE, Pink M, Jobe CM, Kvitne RS. The Shoulder in Sports. In: Rockwood and Matsen, eds. "The shoulder". 2nd ed. Philadelphia: W. B. Saunders Company; 1993: 337-379.

5. Tytherleigh-Strong G, Walls N, McQueen MM. The Epidemiology of Humeral shaft fracture. J Bone Joint Surg Br. 1998;80(2):249-53.
6. Pritsch M, Greental A. Closed pinning for humeral fractures. J Bone Joint Surg Br. 1997;79:412-7.
7. Resch H, Povacz P, Fröhlich R, Wambacher M. Percutaneous pinning of 3-4 part fractures of the proximal humerus. J Bone Joint Surg Br. 1997;79(2):295-300.
8. Krishtiansen B, Kofoed H. External fixation of displaced fractures of proximal humerus. Technique and preliminary results. J Bone Joint Surg Br. 1987;69(4):643-6.
9. Lill H, Heep P, Rose T. The angle stable locking-proximal-humerus plate for proximal humeral fractures using a small anterior-lateral deltoid-splitting-approach. Zenthralbl Chir. 2004;129(1):43-8.
10. Calvo E, de Miguel I, de la Cruz JJ, Lo´pez- Mart´ın N. Percutaneous fixation of displaced proximal humeral fractures: indications based on the correlation between clinical and radiographic results. J Shoulder Elbow Surg. 2007;16(6):774–81.
11. Jaberg H, Warner JJP, Jakob RP. Percutaneous stabilization of unstable fractures of the humerus. J Bone Joint Surg. 1992;74(4):508–15.
12. Alexa O, Puha B, Veliceasa B, Popia I. Percutaneous pinning for proximal humerus fractures. Revista Medico- Chirurgicala a Societatii de Medici si Naturalisti din Iasi's. 2007;111(1):184–9.
13. Keener JD, Parsons BO, Flatow EL, Rogers K, Williams GR, Galatz LM. Outcomes after percutaneous reduction and fixation of proximal humeral fractures. J Shoulder Elbow Surg. 2007;16(3):330–8.
14. Harrison AK, Gruson KI, Zmistowski B, Keener J, Galatz L, Williams G, et al. Intermediate outcomes following percutaneous fixation of proximal humeral fractures. J Bone Joint Surg. 2012;94(13):1223–8.
15. Olerud P, Ahrengart L, Ponzer S, Saving J, Tidermark J. Internal fixation versus nonoperative treatment of displaced 3-part proximal humeral fractures in elderly patients: a randomized controlled trial. J Shoulder Elbow Surg. 2011;20(5):747-55.
16. Fjalestad T, Hole M, Hovden IA, Blu¨cher J, Strømsøe K. Surgical treatment with an angular stable plate for complex displaced proximal humeral fractures in elderly patients: a randomized controlled trial. J Orthopaedic Trauma. 2012;26(2):98–106.
17. Robinson CM, Page RS. Severely impacted valgus proximal humeral fractures. J Bone Joint Surg. 2004;86(2):143–55.
18. Clavert P, Adam P, Bevort A, Bonnomet F, Kempf JF. Pitfalls and complications with locking plate for proximal humerus fracture. J Shoulder Elbow Surg. 2010;19(4):489–94.
19. Egol KA, Ong CC, Walsh M, Jazrawi LM, Tejwani NC, Zuckerman JD. Early complications in proximal humerus fractures (OTA types 11) treated with locked plates. J Orthopaedic Trauma. 2008;22(3):159–64.
20. Yang H, Li Z, Zhou F, Wang D, Zhong B. A prospective clinical study of proximal humerus fractures treated with a locking proximal humerus plate. J Orthopaedic Trauma. 2011;25(1):11–7.
21. Jost B, Spross C, Grehn H, Gerber C. Locking plate fixation of fractures of the proximal humerus: analysis of complications, revision strategies and outcome. J Shoulder Elbow Surg. 2013;22(4):542-9.
22. Hertel R, Hempfing A, Stiehler M, Leunig M. Predictors of humeral head ischemia after intracapsular fracture of the proximal humerus. J Shoulder Elbow Surg. 2004;13(4):427–33.
23. Bastian JD, Hertel R. Initial post-fracture humeral head ischemia does not predict development of necrosis. J Shoulder Elbow Surg. 2008;17(1):2–8.
24. Darder A. Darder AJ. Four part displaced proximal humerus fractures; operative treatment using Kirschner wire and a tension band. J Orthop Trauma. 1993;7(6):497-505.
25. Esser RD. Treatment of three and four part fractures of the proximal humerus with a modified cloverleaf plate. J Orthop Trauma. 1994:788–91.
26. Wijgman AJ, Roolker W, Patt TW. Open reduction and internal fixation of three and four- part fractures of the proximal part of the humerus. J Bone Joint Surg Am. 2002;84:1919–2.
27. PaavoIainen, P.Bjorkenhelm JM, Slatis P, Paukku P. Operative treatment of severe proximal humeral fractures. Acta Orthop Scand. 1983;54:374-9.

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