Evaluation of the results of management of fracture proximal humerus using locking plate

Hisham Elmowafy, Bahaa Zakarya, Mohamed Saeed

Orthopeadic Surgery Department, Faculty Of Medicine, Menoufyia University, Menoufyia, Egypt
egyptness@hotmail.com

Abstract: Aim of the work: To evaluate the results of using locking plate fixation for proximal humerus fractures. **Methods:** Functional outcomes of 13 men and 4 women aged 30 to 85 (mean, 57) years who underwent Philos plate fixation for proximal humeral fractures were retrospectively reviewed. Indications for surgery were 2-part (8/17), 3-part (6/17) or 4-part (3/17) closed proximal humeral fractures with angulation of more than 45 degrees or displacement of more than 1 cm. Functional outcomes and shoulder range of movement were assessed based on the Constant scoring system. **Results:** Patients were followed up for 12 months. Most of the fractures healed satisfactorily (14/17) while (3/17) cases unsatisfactorily. Superficial wound infection was recorded in 2 cases, Avascular necrosis in 2 cases, Shoulder stiffness in 3 cases. Functional outcome were excellent in 4/17 cases, good in 10/17, fair in 1/17 and poor in 2.**Conclusion:** Locking plate fixation is the treatment of choice for the multi-fragmentary fractures of proximal humerus.

[Hisham Elmowafy, Bahaa Zakarya, Mohamed Saeed. **Evaluation of the results of management of fracture proximal humerus using locking plate.** *J Am Sci* 2014;10(10):20-28]. (ISSN: 1545-1003). http://www.jofamericanscience.org. 5

Key words: Humerus, locking, plate, fracture, philos

1. Introduction

Fractures of the proximal humerus are common and have been reported to account for approximately 5% of all fractures [1].

Eighty percent of these fractures are minimally displaced and yield good functional results with conservative treatment. However, when the fracture is unstable, surgical intervention is indicated [2].

Surgical treatment of unstable proximal humeral fractures aims to achieve anatomic reduction and stability for a satisfactory functional outcome. Various techniques, such as percutaneous pinning, tension band techniques, plate fixation, intermeddulary nailing and hemiarthroplasty haven been described to restore biomechanical stability [2,3,4,5,6].

In elderly patients with comminuted fractures, conventional plate osteosynthesis have been associated with hardware problems because of lack of suffiecient purchase, and it has been suggested that minimally invasive stabilization techniques may not allow early rehabilitation because of poor stability [7,8].

Locked compression plate ensures stable fixation of the humeral head and its surrounding fragments, even in poor quality bones, thereby facilitating early rehabilitation [9,10].

2. Materials and Methods

The surgeon needs to be familiar with three approaches to the shoulder. The deltopectoral approach can be used for most fractures [11,12]. The superior approach gives access to the subacromial space without any need for transacromial osteotomy or detachment of the middle deltoid origin [13,14]. The posterior approach is necessary for posterior and inferior glenoid fractures or a malunited greater tuberosity fracture, but this approach is seldom necessary for ORIF of acute proximal humeral fractures or for prosthetic replacement [15,16].

Place the patient in the beach-chair position with the c-arm placed over the shoulder and draped into the sterile field. The c-arm fluoroscopic image intensifier provides an anteroposterior view of the glenohumeral joint, and the humerus can be rotated to obtain radiographs of the shoulder in internal and external rotation [17].

A standard deltopectoral approach is used for proximal humerus. The cephalic vein is routinely taken medially to prevent inadvertent injury during retractor placement. The sub deltoid space is developed. After release of the subdeltoid space, a Browne deltoid retractor is carefully placed under the muscle to facilitate exposure. A second Mayo stand may be used so that the arm can be placed into an abducted posture to minimize the deltoid tension. The clavipectoral fascia is identified and released [18].

The subcoracoid space is developed next, and the axilliary nerve is identified by gentle palpation at the inferior margin of the subscapularis muscle. If necessary, up to 25% of the lateral conjoined tendon may be off the lateral tip of the coracoids to facilitate exposure. To minimize inadvertent stretch of the musculocutaneous nerve, the surgeon should avoid placing self retaining retractors under the conjoined tendon [18].

The biceps tendon is palpated deep to the pectoralis major the biceps may be interposed in the fracture fragments and may require mobilization. Care should be taken to avoid excessive disruption and cauterization through the bicipital groove in an effort to preserve the ascending branch of the anterior circumflex humeral artery. This branch is located laterally in the groove and is the primary blood supply to the head fragment. If the biceps tendon is frayed or appears to be at risk of rupture, a sub pectoral tenodesis can be performed after definitive fixation. This will eliminate a potential source of pain and prevent the possibility of Postoperative rupture. [18]

In the event of a fracture-dislocation, the head is generally located anterior and medial to the glenoid along the glenoid neck. In certain circumstances, there may be a large Hill-Sachs defect of the humeral head fragment after it is impaled on the anterior rim of the glenoid. In this situation, all releases should be performed first, including release of the pectoralis major tendon and lateral conjoined tendon as well as release of the subcoracoid and subdeltoid spaces. A key elevator or a Cobb elevator can be used to assist in prying and relocating the head fragment back into the joint. [18]

Over pulling on the fragment should be avoided, to prevent inadvertent injury to the neurovascular structures lying in close proximity. When a diminished radial pulse is noted on preoperative assessment in a patient with a fracture-dislocation, it may be prudent to have a vascular surgeon immediately available at the time of fracture relocation should a vascular injury be encountered [18,19,20].

After adequate removal of fracture debris, the head is reduced into proper anatomic alignment. A finger can be placed through the rotator interval into the joint to assist with proper orientation. Typically, the head fragment falls into varus positioning. With the assistance of a key elevator, the head can be elevated back into proper alignment typically, after elevation of the head fragment; a large metaphyseal void will exist as a result of the overall fracture comminution. In this situation. A bulk structural allograft (tricortical iliac crest graft, fibular cortical allograft) to help buttress the head fragment and prevent loss of reduction postoperatively. The graft is placed intramedullary within the shaft of the proximal canal, and the shaft is reduced as the head is impacted onto the prominent allograft. [18,19].

Next, a 2-mm Kirschner wire (Kwire) is placed through the upper margin of the head fragment, and the wire is driven through the articular cartilage into the glenoid to help maintain reduction of the head. Alternatively, the humeral head can be pinned to the humeral shaft to help maintain reduction. The wire is bent to avoid interference with the application of the plate. [18,19]

Fluoroscopy is used to confirm proper head positioning. If it is unacceptable, the wire is removed, and the head is manipulated and pinned again until acceptable reduction is established. Once the humeral head is correctly positioned in the joint, the tuberosities are brought beneath the head to buttress the articular segment. [18,19]

The traction sutures in the front and back of the rotator cuff are used to assist in reduction of the tuberosities. The shaft is then reduced to the proximal segment and provincially held in place with a 2-mm K-wire. The overall alignment is verified with fluoroscopy. If there is a large greater tuberosity fragment, another K-wire can be placed through the posterior shoulder below the posterolateral acromion and into the tuberosity to help maintain reduction.The tuberosities are then reduced around the allograft. In situations of extreme comminution, use of a structural allograft to fill the void that may persist. It was found that to be beneficial in maintaining postoperative alignment and preventing varus collapse of the head fragment in patients with compromised bone [18,19].

Plating

Once reduction is confirmed, an appropriately sized internal fixation plate is selected. Design aspects important in plate include :

1) a low profile to minimize overhead impingement.

2) divergent proximal locking screw options to improve fixation in the head and reduce the risk of pullout.

3) suture eyelets on the plate that allow for stable tuberosity fixation and compression.

4) Head screws that match the anatomic neck-shaft angle of the proximal humerus.

General recommendations are to position the plate just lateral to the bicipital groove, with the upper portion of the plate sitting 2 to 3 cm distal to the top of the humeral head [18,19].

3. Results

In the present study, the excellent and good results were considered as satisfactory while the unsatisfactory included the fair and poor results.

Twenty patients underwent this study, Seventeen attended the final follow up, the results at the end of this study were satisfactory in (14) patients (82.35 %) and unsatisfactory in (3) patients (17.64 %). Three patients were lost during the follow up period, so they are not included in the final results.

Table 1

Results		Number of patients	Percentage
Satisfactory	Excellent	4	23.52 %
	Good	10	58.82 %
Unsatisfactory	Fair	1	5.88 %
	Poor	2	11.76 %
TOTAL		17	100%

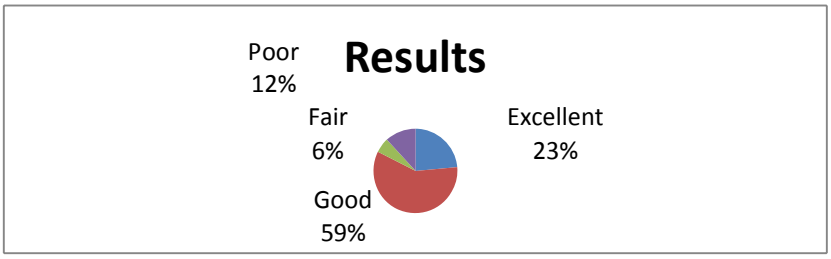


Figure 1.

Post-operative ambulation:

The start of passive movement of the shoulder ranged from 2 - 4 weeks post-operatively.

Table 2:

Post Operative Ambulation	Number of patients	Percentage
2nd week	13	76.47 %
2nd – 4th weeks	4	23.52 %
TOTAL	17	100%

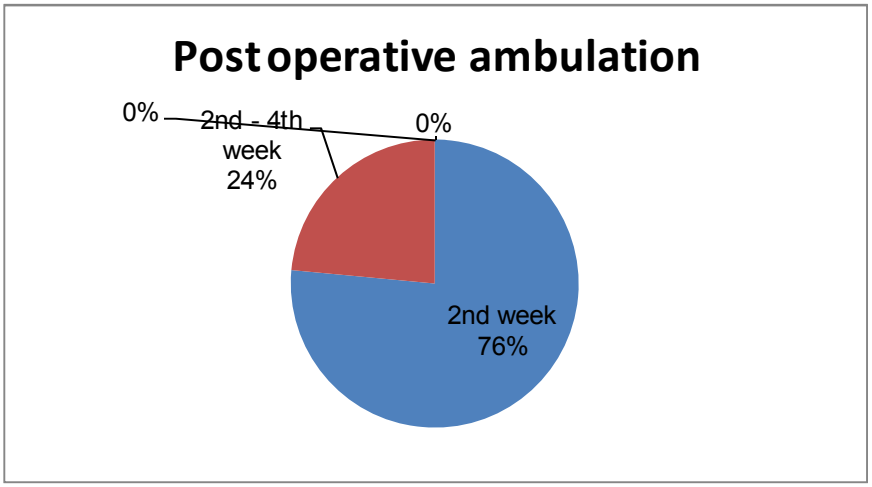


Figure2

Post-operative Pain:

Level of pain was assessed with the start of passive movements where most of patients experienced moderate pain.

Table 3:

Post Operative pain	Number of patients	Percentage
Mild	4	35.29 %
Moderate	10	29.41 %
Sever	2	11.76 %
TOTAL	17	100%

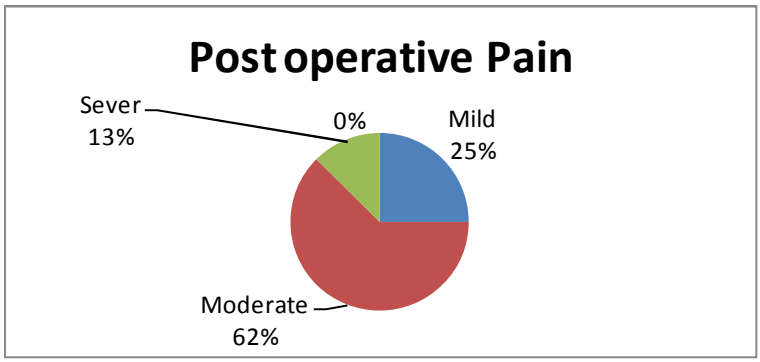


Figure 3

Post-operative radiological union:

Union occurred in 14 patients (82.35 %). The time of union ranged from 12 – 16 weeks.

Table 4

Time of union	Number of patients	Percentage
12 weeks	5	29.41 %
12 – 14 weeks	7	41.18 %
14– 16 weeks	3	17.65 %
Non-union	2	11.76 %
TOTAL	17	100%

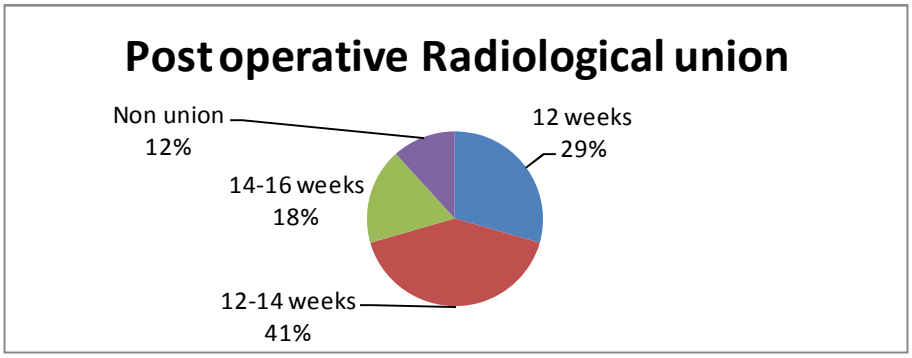


Figure 4:

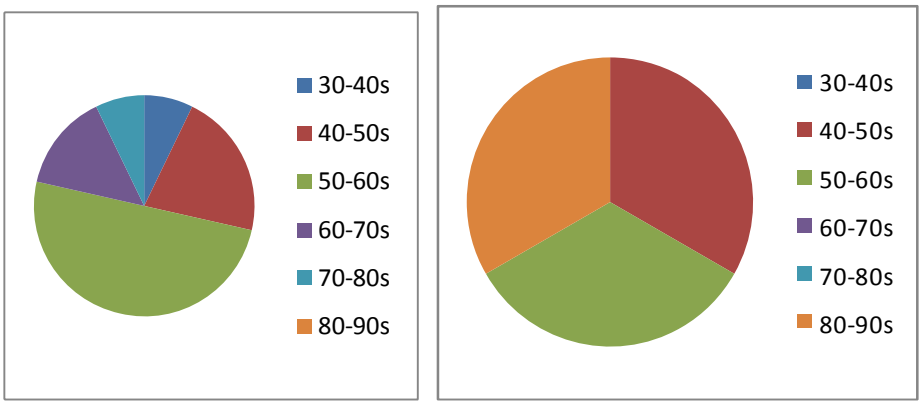
Factors affecting the results:

[1] Age and the end results:

The highest incidence of satisfactory results was in the age (50-60) about (41.17 %) :

Table 5

Age (years)	Satisfactory						Unsatisfactory						Total	
	Excellent		Good		Subtotal		Fair		Poor		Subtotal			
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
30-40s	1	5.88	-	-	1	5.88	-	-	-	-	-	-	1	5.88 %
40-50s	1	5.88	2	11.76	3	17.64	-	-	1	5.88	1	5.88	4	23.52 %
50-60s	2	11.76	5	29.41	7	41.17	1	5.88	-	-	1	5.88	8	47.05 %
60-70s	-	-	2	11.76	2	11.76	-	-	-	-	-	-	2	11.76 %
70-80s	-	-	1	5.88	1	5.88	-	-	-	-	-	-	1	5.88 %
80-90s	-	-	-	-	-	-	-	-	1	5.88	1	5.88	1	5.88 %
Total	**4**	**23.52**	**10**	**58.82**	**14**	**82.35**	**1**	5.88	**2**	11.76	**3**	17.64	**17**	**100 %**



Satisfactory results **unsatisfactory results**

Figure 5

[2] Sex and the end results :

Male gave better results than females. The incidence of satisfactory results in males was 64.7%, while it was 17.6 % in females.

Table 6

Sex	Satisfactory						Unsatisfactory						Total	
	Excellent		Good		Subtotal		Fair		Poor		Subtotal			
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Males	4	23.5	7	41.2	11	64.7	1	5.88	1	5.88	2	11.7	13	76.5
Females	0	0	3	17.6	3	17.6	0	0	1	5.88	1	5.88	4	23.5
Total	**4**	**23.5**	**10**	**58.8**	**14**	**82.3**	**1**	**5.88**	**2**	**11.8**	**3**	**17.6**	**17**	**100**

Table 7

Side affected	Satisfactory						Unsatisfactory						Total	
	Excellent		Good		Subtotal		Fair		Poor		Subtotal			
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Right	3	17.6	7	42.2	10	58.8	1	5.88	2	11.8	3	17.6	13	76.5
Left	1	5.88	3	17.6	4	23.5	0	0	0	0	0	0	4	23.5
Total	4	23.5	10	58.8	14	82.4	1	5.88	2	11.8	3	17.6	17	100

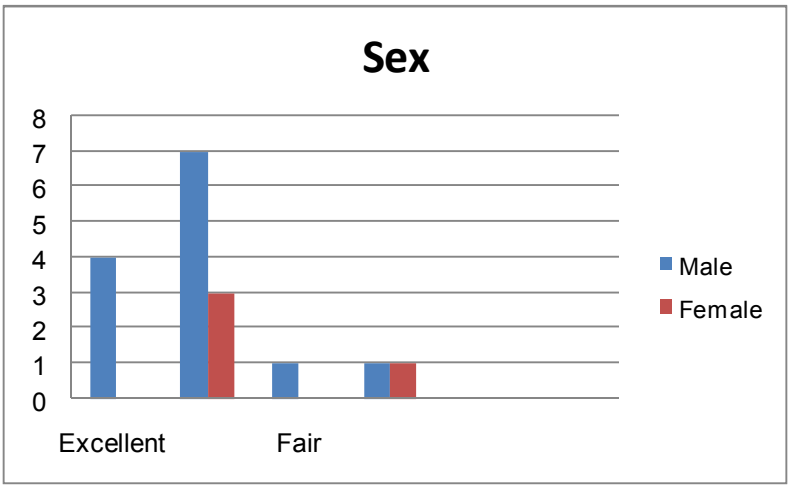


Figure 6

[3] Side affected and the end results:

The highest incidence of satisfactory results was obtained on the right side (58.8 %) **:**

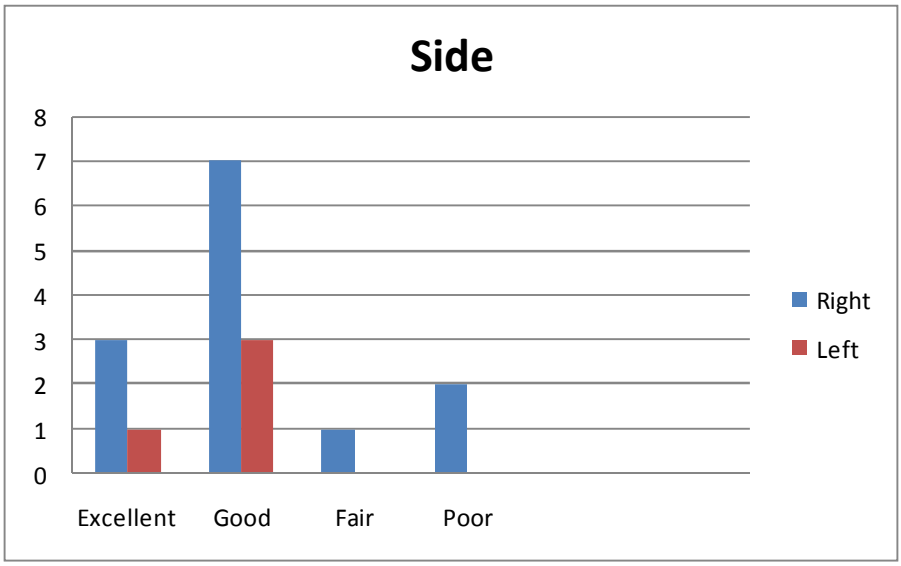


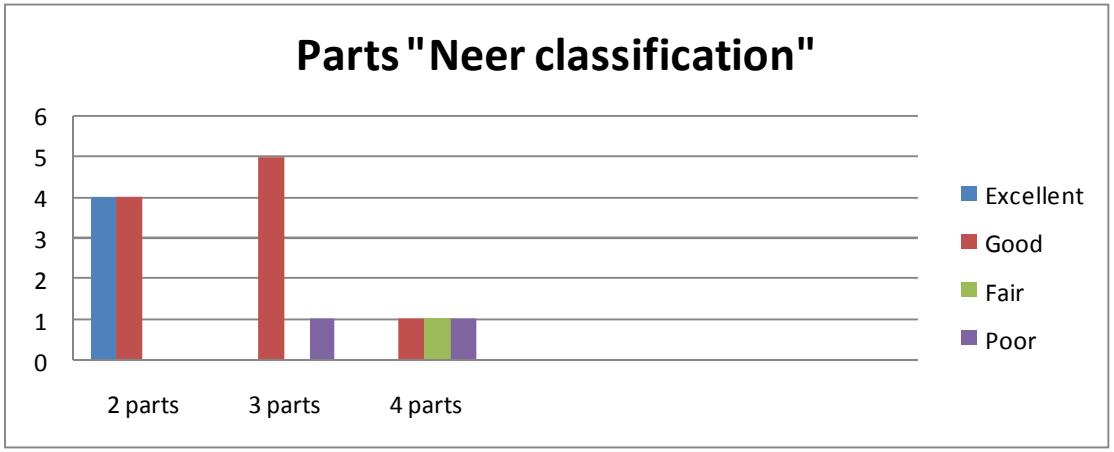
Figure 7

[4] Type of fracture and the end results:

The highest incidence of satisfactory results was present with two parts fractures (47.5%) according to Neer's classification, while the highest incidence of unsatisfactory results was found with four parts fracture dislocation according to Neer's classification (11.8%).

Table 8

Type of fracture	Satisfactory						Unsatisfactory						Total	
	Excellent		Good		Subtotal		Fair		Poor		Subtotal			
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
2 parts	4	23.5	4	23.5	8	47.05	0	0	0	0	0	0	8	47.05
3 parts	0	0	5	29.4	5	29.4	0	0	1	5.88	1	5.88	6	35.3
4 parts	0	0	1	5.88	1	5.88	1	5.88	1	5.88	2	11.8	3	17.6
TOTAL	4	23.5	10	58.8	14	82.4	1	5.88	2	11.8	3	17.6	17	100



Figutr 8

Complications and the end results:

1-Infection and the end results:

Two patients developed post-operative wound infection (11.8%), It was superficial wound infection which has been controlled by antibiotics.

Table 9

Presence of infection	Satisfactory						Unsatisfactory						Total	
	Excellent		Good		Subtotal		Fair		Poor		Subtotal			
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Superficial	0	0	0	0	0	0	1	5.88	1	5.88	2	11.8	2	11.8
Deep	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Absent	4	23.5	10	58.8	14	82.4	0	0	1	5.88	1	5.88	15	88.24
Total	4	23.5	10	58.8	14	82.4	1	5.88	2	11.8	3	17.6	17	100

2-Postoperative shoulder stiffness:

Three patients developed post-operative shoulder stiffness (17.6%) due to pain which delay the rehabilitation of the patients.

Table 10

Post operative shoulder stiffness	Satisfactory						Unsatisfactory						Total	
	Excellent		Good		Subtotal		Fair		Poor		Subtotal			
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Present	0	0	0	0	0	0	1	5.88	2	11.8	3	17.6	3	17.6
Absent	4	23.5	10	58.8	14	82.4	0	0	0	0	0	0	14	82.4
Total	4	23.5	10	58.8	14	82.4	1	5.88	2	11.8	3	17.6	17	100

3-Avascular necrosis and end results:

Two patient showed avascular necrosis of the head of the humerus and collapse of the head (11.8 %), with three and four parts fracture, with limitation of range of motion and sever pain which become tolerable later.

Table 11

Avascular necrosis	Satisfactory						Unsatisfactory						Total	
	Excellent		Good		Subtotal		Fair		Poor		Subtotal			
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Present	0	0	0	0	0	0	0	0	2	11.8	2	11.8	2	11.8
Absent	4	23.5	10	58.8	14	82.4	1	5.88	0	0	1	5.88	15	88.24
Total	4	23.5	10	58.8	14	82.4	1	5.88	2	11.8	3	17.6	17	100

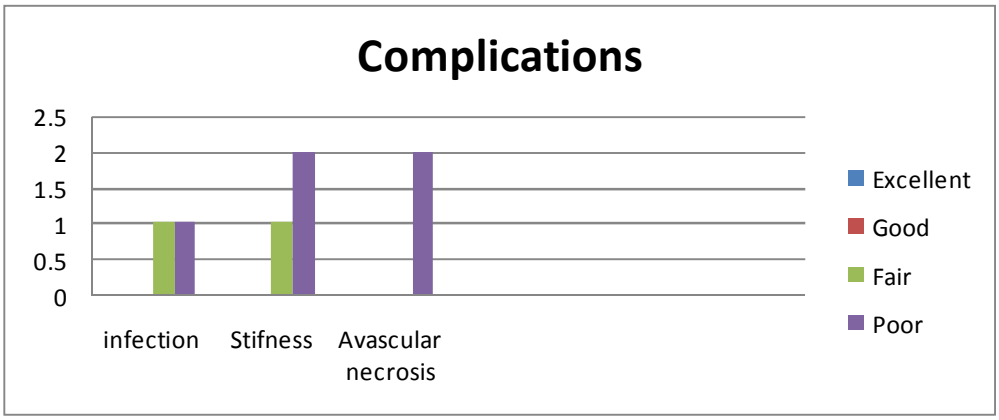


Figure 9

4. Discussion

Most proximal humerus fractures call for conservative treatment. Some unstable and complex fractures require surgical treatment. Several techniques and devices have been used for the fixation of these fractures. The main goal of treatment is the restitution of limb function. Open reduction, in spite of the morbidity of surgical access, allows a more anatomical reduction of the fracture. Rigid fixation with locking plate favors immediate assisted mobility, avoiding stiffness and pain as sequela of the fracture. The majority of our patients have been satisfied with the outcome of their surgery. Fracture union was achieved in almost all the patients of this study.

Analysis of the data has revealed that patients aged (50 – 60 years old) tended to have good results from surgery. Due to the randomized selection of the patients in our study with increased number of old aged patients in relation to younger patients, the results in comparison to age group can't be a reference for evaluation.

The increasing number of displaced parts of the fracture did not seem to have a direct correlation to the final functional outcome score. However, the complication rate seems to increase with the increasing number of fracture parts, reflecting the difficulty of treatment of more complex fracture configurations. We were unable to demonstrate any convincing correlation between the time from injury to surgery and functional outcome although surgery on a relatively new fracture is undoubtedly easier.

It has been difficult to compare the results of our study to those of other studies, owing to differing inclusion and exclusion criteria and to the variety of shoulder scoring systems used. Even in spite of this we feel that our results are comparable to other similar publications.

Many published results for locking plates at the proximal humerus as well as our experience are all very promising. In **Fankhauser, et al.,** [21], **Gallo, et al.,** [22] and **Hente, et al.,** [23] with a relevant indication, we currently see stabilization with the locking plate fixation procedure as the treatment of choice for the multi-fragmentary fractures of the proximal end humerus especially in less mineralized bone (osteoporotic bone), which resembles our results (highest incidence of satisfactory results in age group 50 – 60 years old). Fankhauser, et al [21] noted loss of proximal screw fixation and varus malalignment in 10% of cases. They recommended augmenting the proximal fixation with sutures placed through the rotator cuff and attached to the Locking Compression Plate.

The study of Atalar et al [24] and also the study of Plecko and Kraus [25] reported good results with a Locking plate to other similar publications. In the study of Altalar et al [24], 10 patiens treated with minimally invasive bone grafting and sutureing had an average DASH score of 23, This is comparable to our age groups (average 50.6 years) those had a DASH score of 27.5. **Plecko and Kraus** [25] reported good results with a Locking Proximal Humeral Plate. Their series of 36 patients (average age 57.5 years) had a DASH score of 18. However, it appears that they were more selective about the patients included in their study, choosing to exclude "comminuted humeral head fractures in old patients that cannot be reconstructed properly".

The rate of union in our series is 15 of 17 cases (88.24%) (regarding the fewer cases of the study). The published results of both **Bjorkenheim et al** [26] and **Charalambous et al** [27] with the PHILOS plate, achieving union in 70/72 (97.2%) and 20/25 (80%) respectively. These papers also noted problems with implant failure, screw protrusion and backing-out at rates of 3% (2/72) and 16% (4/25) respectively. **Bjorkenheim et al** [26] found no such complication with the PHILOS plate in their study. The main advantage of the PHILOS plate is apparent in elderly patients, as **Bjorkenheim et al** [26] found no failure of the internal fixation in this particular group and they could attain an activity level that was sufficient to satisfy their patients' needs regarding independent daily living. The plate can even withstand a new fall [23].

Rose et al [28] reported good anatomical reduction that was achieved in the majority of the patients with near anatomic fixation. In our study, anatomical reduction was achieved in 13/17 (76.47%).

Martinez [29] published that philos plate fixation was suitable for even 3 and 4 parts proximal humeral fractures. Its complication rate was low, probably because the patients were relatively young, and both the bone quality and the surgical technique were good [29]. In our study, the complications were found in 4/17 cases (23.53 %). Two of them were (3 parts fracture) while the other two were (4 parts fracture).

Conclusion

- Stabilization and better alignment with a locking plate fixation made it the treatment of choice for the multi-fragmentary fractures of the proximal humerus.
- Locking plate gave better results in less mineralized bone.
- Major satisfactory results were found in fractures with less comminution.
- Male gave better results than females.

Corresponding Author:
Hisham Mohamed Elmowafy, MD
Address: Orthopeadic surgery department, Faculty of medicine, Menoufyia University, Menoufyia.

References

1. Bigliani LU. Fractures of the proximal humerus. In: Rockwood CA, Matsen FA, editors. The shoulder. Philadelphia: Saunders; 1990.
2. Neer C.S. II. Displaced proximal humeral fractures. I. Classification and evaluation. J Bone Joint Surg Am 1970;52:1077-89.
3. Zyto K, Ahrengart L, Sperber A, Tornkvist H. Treatment of displaced proximal humeral fractures in elderly patients. J Bone Joint Surg Br 1997;79:412-7.
4. Kralinger F, Schwaiger R, Wambacher M, Farrell E, Menth-Chiari W,Lajtai G, et al. Outcome after primary hemiarthroplasty for fracture ofthe head of the humerus. A retrospective multicentre study of 167 patients. J Bone Joint Surg Br 2004;86:217-9..
5. Park MC, Murthi AM, Roth NS, Blaine TA, Levine WN, Bigliani LU Two-part and three-part fractures of the proximal humerus treated with suture fixation. J Orthop Trauma 2003;17:319-25.
6. Rajasekhar C, Ray PS, Bhamra MS. Fixation of proximal humeral fractures with the Polarus nail. J Shoulder Elbow Surg 2001;10:7-10.
7. Resch H, Povacz P, Frohlich R, Wambacher M. Percutaneous fixation of three- and four-part fractures of the proximal humerus. J Bone Joint Surg Br 1997;79:295-300.
8. Bernard J, Charalambides C, Aderinto J, Mok D. Early failure of intramedullary nailing for proximal humeral fractures. Injury 2000;31:789-92.
9. Hintermann B, Trouillier HH, Schafer D. Rigid internal fixation of fractures of the proximal humerus in older patients. J Bone Joint Surg Br 2000;82:1107-12.
10. Churl-Woo Lee, MD, Sang-Jin Shin, MD. Prognostic factors for unstable proximal humeral fractures treated with locking-plate fixation. J Shoulder Elbow Surg 2009 18, 83-88.
11. Esser RD: Treatment of three- and four-part fractures of the proximal humerus with a modified cloverleaf plate. J Orthop Trauma 1994;8:15-22.
12. Szyszkowitz R, Seggl W, Schleifer P, Cundy PJ: Proximal humeral fractures: Management techniques and expected results. Clin Orthop Relat Res 1993;292:13-25.
13. DePalma AF, Cautilli RA: Fractures of the upper end of the humerus. Clin Orthop 1961;20:73-93.
14. Sturzenegger M, Fornaro E, Jakob RP: Results of surgical treatment of multifragmented fractures of the humeral head. Arch Orthop Trauma Surg 1982;100:249-259.
15. Owsley K, Gorcyzka J: Displacement/ screw cutout after open reduction and locked plate fixation of humeral fractures. J Bone Joint Surg Am 2008;90: 233-240.
16. Sturzenegger M, Fornaro E, Jakob RP: Results of surgical treatment of multifragmented fractures of the humeral head. Arch Orthop Trauma Surg 1982;100:249-259.
17. Paavolainen P, Bjorkenheim JM, Slatis P, Paukku P: Operative treatment of severe proximal humeral fractures. Acta Orthop Scand 1983;54:374-379.
18. Neer, C.S., II. Fractures about the shoulder. In: Rockwood, C.A.; Greene, D.P., eds. Fractures in Adults. Philadelphia, J.B. Lippincott, 1984.
19. Norris, T.R. Fractures and dislocation of the glenohumeral complex. In: Chapman, M.W.; Madison, M., eds. Operative Orthopaedics. Philadelphia, J.B. Lippincott, 1988, pp. 203–220.
20. Szalay, E.A.; Rockwood, C.A., Jr. Injuries of the shoulder and arm. Emerg Med Clin North Am 2:279–294, 1984.
21. Fankhauser,et al,F.,Bolding, C.,Schippinger, G., Haunschmid, C., Szyszkowitz, R.: A new locking plate for unstable fractures of the proximal humerus. Clin. orthop., 176–181, 2005.
22. Gallo, et al, R., A., Zeiders, G., J., Altman, G. T. : Two-incision technique for treatment of complex proximal humerus fractures. J. Orthop. Trauma, 19: 734–740, 2005.
23. Hente, et al, R, Kampshoff, J., Kinner, B., Fuchtmeier, B., Nerlich, M. : Treatment of displaced 3- and 4-part fractures of the proximal humerus with fixator plate comprising angular stability. Unfallchirurg, 107: 769–782, 2004.
24. Ac Atalar, Demishan M, Uysal M, Seyahi A. [Treatment of Neer type 4 impacted valgus fractures of the proximal humerus with open reduction, elevation and grafting.] (in Turkish). Acta Orthop Traumatol Turc 2007 ; 41 : 113-119.
25. Pleko M, Kraus A. Internal fixation of proximal humeral fractures using the locking proximal humeral plate. Oper Orthop Traumatol 2005 ; 17 : 25-50.
26. Bjorkenheim, et al. Internal fixation of proximal humeral fractures with a locking compression plate: a retrospective evaluation of 72 patients followed for a minimum of 1 year. Acta orthop. scand., 75: 41–745, 2004.
27. Charalambous CP, Siddique I, Valluripalli K et al. Proximal humeral internal locking system (PHILOS) for the treatment of proximal humoral fractures. Arch Orthop Trauma Surg. 2007 ; 127 : 205-210.
28. Rose PS, Adams CR, Torchia ME et al. Locking plate fixation for proximal humeral fracture : Initial results with the new implant. J Shoulder Elbow Surg 2007; 16: 202-207.
29. Martinez, AA, J Cuenca, A Herrera Service of Orthopaedic and Trauma Surgery, Miguel Servet University Hospital, Zaragoza, Spain Vol. 17 No. 1, April 2009.

7/19/2014