Annals of Clinical and Medical Case Reports

Research Article

ISSN 2639-8109 | Volume 10

Functional Outcome of Proximal Humerus Fracture Fixation Using Philos System

Inam M, Ulhaq QA, Hassan W* and Khan I

Department of Orthopedics, Medical Teaching Institute Lady Reading Hospital, Peshawar, Pakistan

***Corresponding author:**

Waqar Hassan,
Department of Orthopedics, Medical Teaching Institute Lady Reading Hospital, Peshawar, Pakistan

Received: 10 Apr 2023
Accepted: 24 May 2023
Published: 02 June 2023
J Short Name: ACMCR

Citation:

Hassan W, Functional Outcome of Proximal Humerus Fracture Fixation Using Philos System. Ann Clin Med Case Rep. 2023; V10(22): 1-6

Keywords:

Functional outcome, PHILOS plate, Proximal Humerus Fractures, Shoulder

1. Abstract

Proximal humerus fractures account for 5-6% of all adult fractures. There is increasing recognition given in regard to managing these fractures in the setting of elderly, low-energy falls as these events are contributing to the global impact of direct and indirect costs of osteoporosis and fragility fractures.

1.1. Objective: To determine the functional outcomes of proximal humeral internal locking system in treatment of proximal humerus fractures.

1.2. Materials and Methods: This Descriptive Case Series study was conducted in the Department of Orthopedics and Trauma, Medical Teaching Institute Lady Reading Hospital, Peshawar Pakistan from September 2021 to March 2022. A total of 114 patients of both gender with proximal humerus fracture were included in the study. Patients were called for follow up after 4 weeks of procedure and functional outcome was determined by constant shoulder score.

1.3. Results: Age range in this study was from 18-50 years with mean age of 30.105±5.70 years and mean duration of fracture was 1.394±0.49 Kg. Male patients were 79.8% and females were 20.2%. Excellent functional outcome was seen in 21.9%, good 36%, fair 33.3% and poor was 8.8%.

1.4. Conclusion: It can be concluded that proximal humerus fractures treated with proximal humeral internal locking system (PHILOS) plate has good functional outcome.

2. Introduction

Proximal humerus fractures (PHF) account for 5-6% of all adult fractures [1]. There is increasing recognition given in regard to managing these fractures in the setting of elderly, low-energy falls as these events are contributing to the global impact of direct and indirect costs of osteoporosis and fragility fractures. Moreover, as the general population continues to age and an increasing percentage of these patients are being considered bone density compromised [2], the overall nonoperative and operative management of PHFs continue to receive considerable attention in the literature [3].

Proximal humerus fractures classically fall under a bimodal distribution by age and energy level. This bimodal pattern is very common and clinicians should recognize the high-energy (e.g. Motor vehicle accident in young patients) versus low-energy (e.g. elderly patient status post ground level fall) paradigm in various groups and fracture patterns [4].

Proximal humerus fractures most commonly occur in patients over 65 years of age [5]. In the setting of osteoporosis or osteopenia, a low-energy fall resulting in a PHF is, by definition, a fragility fracture [6].

Orthopedic surgeons have been using various methods for the treatment of proximal humerus fractures as described in the literature, these methods include percutaneous Kirschner wire, closed reduction, open reduction and fixation with sutures, circulating wise, intra medullary nails and plates, prosthetic replacement, T plate and tension band among others [7]. But no procedure is perfect and each one has its own set of complications such as, nonunion of bone, avascular necrosis, impingement of the rotator cuff, implant failure etc. One of the treatment methods is the Proximal Humeral Internal Locking System (PHILOS) system, which is especially useful in the geriatric population who have osteoporotic

bones, it provides better fixation, gives stability, involves minimal disuse damage and has minimal the risk of displacement of the fractured bone [8].

In a study by Jabbar FA, et al. has shown that frequency of excellent functional outcome was 54%, good 24%, fair 14% and poor was 8% after proximal humerus fracture fixation using PHILOS system [9]. In another study by Rao NN, et al. has shown that frequency of excellent functional outcome was 4%, good 44%, fair 44% and poor was 8% after proximal humerus fracture fixation using PHILOS system [10].

PHILOS plate provides rigid fixation, more angular stability and early mobilization. There is variability in results when PHILOS system is used in different populations as shown in above studies [9,10]. Therefore further evidence is needed to evaluate the functional outcomes of proximal humeral internal locking system in treatment of proximal humerus fractures. Results of my study will be useful for practitioners in our general population.

3. Material and Methods

This Descriptive Case Series study was conducted in the Department of Orthopedics and Trauma, Medical Teaching Institute Lady Reading Hospital, Peshawar Pakistan from September 2021 to March 2022. A total of 114 patients of Age 18-50 years both gender with proximal humerus fracture with less than two weeks duration were included in the study while Pathological open fractures, Polytrauma patients with expected delay in immediate primary fixation and Patients with uncontrolled diabetes, patients on chronic steroid therapy and Immuno-compromised patients were excluded from the study. Sample size was calculated using WHO sample size software with 95% confidence interval, 5% margin of error and expected frequency of poor outcome by 8% after proximal humerus fracture fixation using PHILOS system.9 Non-probability consecutive sampling technique was used in the study.

Patients fulfilling the inclusion criteria from indoor Department of Orthopedics, LRH, Peshawar were included in the study after permission from ethical committee. Base line demographic information of patients like age, gender, type of fractures (2, 3, 4 part) were recorded. Informed consent was taken from each patient, ensuring confidentiality and fact that there is no risk involved to the patient while taking part in this study.

All the surgical procedures were performed at a single institute under general anesthesia with the patients lying in a beach chair position, using a deltopectoral approach. Local anesthetic was applied in the skin around the area of procedure. Midway between the clavicle and coracoid process an incision was made which was extended till the insertion of the deltoid muscle. The cephalic vein was retracted laterally while the conjoint tendon was retracted medially. For fragmented tuberosity of the humerus traction sutures with Ticron number 5 and K wires was fixed to the humeral shaft temporarily. Distal to the greater tuberosity at a distance of 5 to 10mm and lateral to the bicipital groove the PHILOS plate was placed, the initial cortical screw was placed and the subsequent screws was placed after confirming the position of the PHILOS plate system, all the drilling to place the locking screws was done under fluoroscopic imaging. At least 5 head screws and 3 bicortical screws was used in the procedures. The tuberosity sutures that was applied earlier was fixed with the PHILOS plate, as doing this provides better functional outcome. Suction drain was used when closing the wound which was removed on the first or second post operative day accordingly. A Sling was used to support the arm. Physiotherapy was started as soon as possible for the patients and it was started with passive forward flexion, pendulum and external rotation exercises (usually from the first post operative day) these exercises was gradually increased up to assisted active exercises starting from the third week of procedure.

Patients were called for follow up after 4 weeks and functional outcome was determined by Constant-Murley Shoulder Score9 as per operational definition on especially designed proforma. Data was analyzed with statistical analysis program (SPSS 23). Mean ±SD was presented for quantitative variables like age and duration of fracture. Frequencies and percentage were computed for categorical variables like gender, type of fracture and functional outcomes. Functional outcomes were stratified for age, gender, type of fracture and duration of fracture. Post stratification chi square test was applied $p \leq 0.05$ was considered statistically significant.

Functional outcomes:

It was evaluated by Constant-Murley Shoulder Score9 after four weeks of procedure.

4. Results

There were total 114 patients having minimum age of 18 years while maximum age was 50 years with mean age of 30.105±5.70 years and mean duration of fracture was 1.394±0.49 days as shown in Table 1.

Male patients were 79.8% and females were 20.2% as shown in Table 2.

Frequency and %age of patients according to type of fracture are shown in Table 3.

Excellent functional outcome was seen in 21.9%, good 36%, fair 33.3% and poor was 8.8% as shown in Table 4.

Stratification of functional outcomes with respect to age, gender, type of fracture and duration of fracture are shown in Table 5-20 respectively.

Table 1: Mean±SD of patients according to age and duration of fracture n=114

Demographics		Mean±SD
1	Age (years)	30.105±5.70
2	Duration of fracture (weeks)	1.394±0.49

Table 2: Frequency and %age of patients according to gender n=114

Gender	Frequency	%age
Male	91	79.80%
Female	23	20.20%
Total	114	100%

Table 3: Frequency and %age of patients according to type of fracture n=114

Type of Fracture	Frequency	%age
2	74	64.90%
3	33	28.90%
4	7	6.10%
Total	114	100%

Table 4: Frequency and %age of patients according to functional outcomes n=114

Functional outcomes	Frequency	%age
Excellent	25	21.90%
Good	41	36%
Fair	38	33.30%
Poor	10	8.80%
Total	114	100%

Table 5: Stratification of Excellent outcome with respect to age.

Age (years)	Excellent outcome		p-value
	Yes	No	
18-35	21(21.9%)	75(78.1%)	0.974
36-50	4(22.2%)	14(77.8%)	
Total	25(21.9%)	89(78.1%)	

Table 6: Stratification of Excellent outcome with respect to gender.

Gender	Excellent outcome		p-value
	Yes	No	
Male	23(25.3%)	68(74.7%)	0.086
Female	2(8.7%)	21(91.3%)	
Total	25(21.9%)	89(78.1%)	

Table 7: Stratification of Excellent outcome with respect to Type of Fracture.

Type of Fracture		Excellent outcome		Total	p-value
		Yes	No		
2	Yes	24(32.4%)	50(67.6%)	74 (100%)	0
	No	1 (2.5%)	39(97.5%)	40(100%)	
	Total	25(21.9%)	89(78.1%)	114 (100%)	
3	Yes	1(3%)	32(97%)	33(100%)	0.002
	No	24(29.6%)	57(70.4%)	81(100%)	
	Total	25(21.9%)	89(78.1%)	114 (100%)	
4	Yes	0(0%)	7(100%)	7(100%)	0.147
	No	25(23.4%)	82(76.6%)	107(100%)	
	Total	25(21.9%)	89(78.1%)	114 (100%)	

Table 8: Stratification of Excellent outcome with respect to duration of fracture.

Duration of fracture (weeks)	Excellent outcome		p-value
	Yes	No	
1	13(18.8%)	56(81.2%)	0.324
>1	12(26.7%)	33(73.3%)	
Total	25(21.9%)	89(78.1%)	

Table 9: Stratification of Good outcome with respect to age.

Age (years)	Good outcome		p-value
	Yes	No	
18-35	33(34.4%)	63(65.6%)	0.414
36-50	8(44.4%)	10(55.6%)	
Total	41(36%)	73(64%)	

Table 10: Stratification of Good outcome with respect to gender.

Gender	Good outcome		p-value
	Yes	No	
Male	32(35.2%)	59(64.8%)	0.723
Female	9(39.1%)	14(60.9%)	
Total	41(36%)	73(64%)	

Table 11: Stratification of Good outcome with respect to Type of Fracture.

Type of Fracture		Good outcome		Total	p-value
		Yes	No		
2	Yes	33(44.6%)	41(55.4%)	74 (100%)	0.009
	No	8 (20%)	32(80%)	40(100%)	
	Total	41(36%)	73(64%)	114 (100%)	
3	Yes	8(24%)	25(76%)	33(100%)	0.096
	No	33(40.7%)	48(59.3%)	81(100%)	
	Total	41(36%)	73(64%)	114 (100%)	
4	Yes	0(0%)	7(100%)	7(100%)	0.04
	No	41(38%)	66(62%)	107(100%)	
	Total	41(36%)	73(64%)	114 (100%)	

Table 12: Stratification of Good outcome with respect to duration of fracture.

Duration of fracture (weeks)	Good outcome		p-value
	Yes	No	
1	24(34.8%)	45(65.2%)	0.745
>1	17(37.8%)	28(62.2%)	
Total	41(36%)	73(64%)	

Table 13: Stratification of Fair outcome with respect to age.

Age (years)	Fair outcome		p-value
	Yes	No	
18-35	32(33.3%)	64(66.7%)	1
36-50	6(33.3%)	12(66.7%)	
Total	38(33.3%)	76(66.7%)	

Table 14: Stratification of Fair outcome with respect to gender.

Gender	Fair outcome		p-value
	Yes	No	
Male	28(30.8%)	63(69.2%)	0.248
Female	10(43.5%)	13(56.5%)	
Total	38(33.3%)	76(66.7%)	

Table 15: Stratification of Fair outcome with respect to Type of Fracture.

Type of Fracture		Fair outcome		Total	p-value
		Yes	No		
2	Yes	16(21.6%)	58(78.4%)	74 (100%)	0
	No	22 (55%)	18(45%)	40(100%)	
	Total	38(33.3%)	76(66.7%)	114 (100%)	
3	Yes	22(66.6%)	11(33.3%)	33(100%)	0
	No	16(19.7%)	65(80.3%)	81(100%)	
	Total	38(33.3%)	76(66.7%)	114 (100%)	
4	Yes	0(0%)	7(100%)	7(100%)	0.053
	No	38(35.5%)	69(64.5%)	107(100%)	
	Total	38(33.3%)	76(66.7%)	114 (100%)	

Table 16: Stratification of Fair outcome with respect to duration of fracture.

Duration of fracture (weeks)	Fair outcome		p-value
	Yes	No	
1	26(37.7%)	43(62.3%)	0.223
>1	12(26.7%)	33(73.3%)	
Total	38(33.3%)	76(66.7%)	

Table 17: Stratification of Poor outcome with respect to age.

Age (years)	Poor outcome		p-value
	Yes	No	
18-35	9(9.4%)	87(90.6%)	0.599
36-50	1(5.6%)	17(94.4%)	
Total	10(8.8%)	104(91.2%)	

Table 18: Stratification of Poor outcome with respect to gender.

Gender	Poor outcome		p-value
	Yes	No	
Male	8(8.8%)	83(91.2%)	0.988
Female	2(8.7%)	21(91.3%)	
Total	10(8.8%)	104(91.2%)	

Table 19: Stratification of Poor outcome with respect to Type of Fracture.

Type of Fracture		Poor outcome		Total	p-value
		Yes	No		
2	Yes	2(2.7%)	72(97.3%)	74 (100%)	0.001
	No	8 (20%)	32(80%)	40(100%)	
	Total	10(8.8%)	104(91.2%)	114 (100%)	
3	Yes	1(3%)	32(97%)	33(100%)	0.166
	No	9(11%)	72(89%)	81(100%)	
	Total	10(8.8%)	104(91.2%)	114 (100%)	
4	Yes	7(100%)	0(0%)	7(100%)	0
	No	3(2.8%)	104(97.2%)	107(100%)	
	Total	10(8.8%)	104(91.2%)	114 (100%)	

Table 20: Stratification of Poor outcome with respect to duration of fracture.

Duration of fracture (weeks)	Poor outcome		p-value
	Yes	No	
1	6(8.7%)	63(91.3%)	0.972
>1	4(8.9%)	41(91.1%)	
Total	10(8.8%)	104(91.2%)	

5. Discussion

In our study, Excellent functional outcome was seen in 21.9%, good 36%, fair 33.3% and poor was 8.8%. In a study by Jabbar FA, et al. has shown that frequency of excellent functional outcome was 54%, good 24%, fair 14% and poor was 8% after proximal humerus fracture fixation using PHILOS system [9]. In another study by Rao NN, et al. has shown that frequency of excellent functional outcome was 4%, good 44%, fair 44% and poor was 8% after proximal humerus fracture fixation using PHILOS system [10].

All of our patients were satisfied with the treatment except for one patient with implant failure who did not progress to union but was able to perform daily activities. Our data analysis showed that elderly patients are more prone to non-union or suboptimal outcome as compared to younger ones. None of our patient required bone grafting. Interestingly number of fracture fragments did not seem to correlate with functional outcome. Plan T plate fixation with 2 cancellous screws resulted in 100% failure rate in elderly patients with osteoporotic bone.10911 Two one third tubular plates fixation has high failure rate of 12% including implant loosening and subacromial impingement [11,12]. Tension band wiring and non-operative treatment had similar functional outcomes [13]. Proximal humerus interlocking system has advantage over other mode of

treatment especially in osteoporotic bones. It has locking screws whose heads are meant to lock in plate holes and also the direction of screws is different in proximal part of plate to grip the proximal humerus in different directions. Direction of screws is such that level A has parallel screws which are slightly upward in direction. B has converging, C diverging; D has slight upward direction relating to anatomical position of plate, E has parallel and upward direction screws for purchase in opposite calcar and F has combination hole for both conventional and locking screws. 3.5 mm screw is placed to adjust the plate vertically. Variety of screw directions are possible in proximal humerus by this combination which is suitable to osteoporotic bone as well. In study of Atalar et al [14], 10 patients treated with minimally invasive bone grafting and suturing had an average DASH score of 23. Pleko and Kraus 15 reported good results with locking proximal humerus plates. They studied 36 patients with DASH score of 18. This is comparable to Constant-Murley Shoulder Score of our study. Bjorkenheim et al reported that locking proximal humeral plate fixation achieved acceptable functional results but non-union and avascular necrosis of humeral head have also been reported [16]. Gardner MJ et al showed in his study that caution is needed in case of comminution in medial calcar during plate fixation [17].

The procedure thought technical and requiring some level of surgical proficiency provides a stable fixation and early mobilization for the patients. In the literature there have been various methods that surgeons have used for fixation of comminuted or displaced fractures of the humerus, and these techniques have their own complications such as avascular necrosis, treatment induced fractures, non union etc, [18-22]. Various studies have shown that locking plate fixation (peri articular) have a better outcome and lesser rate of complications as compared to the non locking plates [23,24]. However the locking plate fixation type of fixation requires more surgical proficiency and care especially regarding the preservation of the soft tissue structures and blood supply and vascularity of the fractured segments during this open reduction and internal fixation technique [25,26]. In our study we utilized the deltopectoral approach in the patients of the proximal humerus fractures, the important points that must be taken care of are the placement of the plate of proper length, using the fluoroscopic imaging when placing the screws in the correct position and avoiding the varus displacement by ensuring support to the medial side of the cortex [27-29].

In the study by Egol et al they had an infection rate of 1.61% in their case series and similar rate of observed in a study by Moonot et al and Gardner et al, in which the patients of infection were treated with antibiotics only [29,30]. The lower rates of infections observed are due to proper aseptic technique, with special care taken to minimize the soft tissue injury.

We did not observe any avascular necrosis in these patients, which could be explained by the fact that humeral head is re-vascularized promptly through the phenomenon of creeping substitution (bone remodeling and formation of new vascular channels via re-absorption of bone by osteoclasts), however a longer duration of follow up might reveal more complications. We recommend further studies be done with longer duration of follow up and larger sample size to further strengthen the use of PHILOS plate as a good treatment option.

6. Conclusion

It can be concluded that proximal humerus fractures treated with PHILOS plate has good functional outcome. Number of fracture

References

1. Schumaier A, Grawe B. Proximal humerus fractures: evaluation and management in the elderly patient. Geriatr Orthop Surg Rehabil. 2018; 9: 2151458517750516.
2. Sözen T, Özışık L, Başaran NÇ. An overview and management of osteoporosis. Eur J Rheumatol. 2017;4(1):46-56.
3. Anley C, Vrettos BC, Rachuene P, Roche SJL. Proximal humerus fractures - part 1: conservative management. SA Orthop J. 2019;18(3):63-71.
4. Aiyer A, Varacallo M, Boateng H, Reid SJ. Humeral shaft fracture with ipsilateral anterior shoulder dislocation and posterior elbow dislocation: a case report and review of the literature. JBJS Case Connect. 2014;4(3):e77-e4.
5. Jaul E, Barron J. Age-related diseases and clinical and public health implications for the 85 years old and over population. Front Public Health. 2017;5:335.
6. Khan AH, Jafri L, Ahmed S, Noordin S. Osteoporosis and its perspective in Pakistan: a review of evidence and issues for addressing fragility fractures. Ann Med Surg. 2018;29:19-25.
7. Beks RB, Ochen Y, Frima H, Smeeing DPJ, van der Meijden O, Timmers TK, et al. Operative versus nonoperative treatment of proximal humeral fractures: a systematic review, meta-analysis, and comparison of observational studies and randomized controlled trials. J Shoulder Elbow Surg. 2018;27(8):1526-34.
8. Zhao L, Qi YM, Yang L, Wang GR, Zheng SN, Wang Q, et al. Comparison of the effects of proximal humeral internal locking system (PHILOS) alone and PHILOS combined with fibular allograft in the treatment of Neer three- or four-part proximal humerus fractures in the elderly. Orthop Surg. 2019;11(6):1003-12.
9. Jabbar FA, Shah RA. Proximal humerus fractures; radiological and functional outcome as treated with the PHILOS plating system, at a tertiary care centre in Karachi, Pakistan. Professional Med J. 2017;24(12):1788- 93.
10. Rao NN, Supradeeptha C. Study on functional outcome of the proximal humeral internal locking system (PHILOS) for displaced proximal humeral fractures in adults. Int J Surg Trauma Orthop. 2019;5(5):355-64.
11. Sadowski C, Riand N, Stern R, Hoffmeyer P. Fixation of fractures of

proximal humerus with PlanTan humerus fixator plate: early experience with a new implant. J Shoulder Elbow Surg 2003;12(2):148–51.

12. Wanner GA, Wanner-Schmid E, Romero J, Hersche O, von Smekal A, TrentzO, et al. Internal fixation of displaced proximal humeral fractures with two one third tubular plates. J Trauma 2003;54(3):536–44.
13. Zyto K, Ahrengart L, Sperber A, Tornkvist H. Treatment of displaced proximal humeral fractures in elderly patients. J Bone Joint Surg Am 1997;79:412–7.
14. Atalar AC, Demishan M, Uysal M, Seyahi A. Treatment of Neer type 4 impacted valgus fractures of proximal humerus with open reduction, elevation and grafting. Acta Orthop Traumatol Turc 2007;41(2):113–9.
15. Pleko M, Kraus A. Internal fixation of proximal humeral fractures using the proximal humeral fractures using the locking proximal humeral plates. Oper Orthop Traumatol 2005;17(1):25–50.
16. Bjorkenheim JM, Pajarinen J, Savolainen V. Internal fixation of proximal humeral fractures with locking compression plate: a retrospective evaluation of 72 patients followed for a minimum of 1 year. Acta Orthop Scand 2004;75(6):741–5.
17. Gardner MJ, Weil Y, Barker JU, Kelly BT, Helfet DL, Lorich DG. The importance of medial support in locked plating of proximal humerus fractures. J Orthop Trauma 2007;21(3):185–91.
18. Park MC, Murthi AM, Roth NS, et al. Two-part and threepart fractures of the proximal humerus treated with suture fi xation . J Orthop Trauma 2003; 17(5):319- 25.
19. Ogiwara N, Aoki M, Okamura K, et al. Ender nailing for unstable surgical neck fractures of the humerus in elderly patients . Clin Orthop Relat Res 1996; (330):173-80.
20. Resch H, Povacz P, Fröhlich R, et al. Percutaneous fixation of three- and four-part fractures of the proximal humerus . J Bone Joint Surg Br 1997; 79(2):295-300.
21. Robinson CM, Page RS, Hill RM, Sanders DL, Court-Brown CM, Wakefield AE. Primary hemiarthroplasty for treatment of proximal humeral fractures . J Bone Joint Surg Am 2003; 85(7):1215- 23.
22. Siffri PC, Peindl RD, Coley ER, et al. Biomechanical analysis of blade plate versus locking plate fixation for a proximal humerus fracture: comparison using cadaveric and synthetic humeri . J Orthop Trauma 2006;20(8):547-54.
23. Walsh S, Reindl R, Harvey E, Berry G, Beckman L, Steffen T. Biomechanical comparison of a unique locking plate versus a standard plate for internal fixation of proximal humerus fractures in a cadaveric model . Clin Biomech 2006; 21(10):1027-31.
24. Papadopoulos P, Karataglis D, Stavridis SI, et al. Midterm results of internal fixation of proximal humeral fractures with the PHILOS plate . Injury 2009; 40(12):1292-6.
25. Gardner MJ, Weil Y, Barker JU, Kelly BT, Helfet DL, Lorich DG. The importance of medial support in locked plating of proximal humerus fractures . J Orthop Trauma 2007; 21(3):185-91.
26. Wijgman AJ, Roolker W, Patt TW, Raaymakers EL, Marti RK. 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(11):1919-25.
27. Gardner MJ, Voos JE, Wanich T, Helfet DL, Lorich DG. Vascular implications of minimally invasive plating of proximal humerus fractures . J Orthop Trauma 2006; 20(9):602-7.
28. Liew AS, Johnson JA, Patterson SD, King GJ, Chess DG. Effect of screw placement on fixation in the humeral head . J Shoulder Elbow Surg 2000; 9(5):423-6.
29. Egol KA, Ong CC, Walsh M, et al. Early complications in proximal humerus fractures (OTA Types 11) treated with locked plates . J Orthop Trauma 2008; 22(3):159-64.
30. Moonot P, Ashwood N, Hamlet M. Early results for treatment of three- and four-part fractures of the proximal humerus using the PHILOS plate system . J Bone Joint Surg Br 2007; 89(9):1206-9.