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Original Research Article

# Results of proximal humeral locking plate fixation in Neer's two and three part proximal humerus fractures: A retrospective analysis of twenty patients

**Manjeet S Dhanda[1], Nadeem Ali[2*], Abedullah Bhat[2], Firdous A Bangroo[2], Sansar C Sharma[3], Mehreen Maqsood[4], Sagar Parashar[5], Arti Dhingra[6]**

[1]Assistant Professor, Department of Orthopedics, SHKM Govt Medical College, Mewat, Haryana, India
[2]Senior Resident, Department of Orthopedics, SHKM Govt Medical College, Mewat, Haryana, India
[3]Director and Professor, Department of Orthopedics, SHKM Govt Medical College, Mewat, Haryana, India
[4]Junior Resident, Department of Anesthesia, Government Medical College Jammu, J&K, India
[5]Junior Resident, Department of Orthopedics, SHKM Govt Medical College, Mewat, Haryana, India
[6]Assistant Professor, Department of Pediatrics, SHKM Govt Medical College, Mewat, Haryana, India
[*]Corresponding author email: drnadeeem@gmail.com

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## Abstract

**Background:** Fractures of the proximal humerus have been a challenge to orthopaedic surgeons with treatment modalities changing from time to time. Locking plates have revolutionised the treatment of these fractures. Currently proximal humeral locking plates (PHLP) and proximal humeral interlocking osteosynthesis (PHILOS) are two types of locking plates available for fixation of these fractures. Aim of this study was to evaluate the results of proximal humeral locking plate (PHLP) for Neers's two and three part proximal humerus fractures.

**Material and methods:** Neer's two and three part fractures treated by open reduction and internal fixation with proximal humeral locking plate from August 2012 to April 2014 were retrospectively

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evaluated for complications, time to radiological union and final functional outcome using Constant-Murley Score (CMS).

**Results:** Twenty (12 male; 8 female) patients with 8 Neer's 2-part and 12 Neer's 3-part fractures managed by open reduction and internal fixation with proximal humeral locking plate (PHLP) with an average follow up of 23.2 months were evaluated. All the fractures united at an average of 16 (12 to 20) weeks. Eight complications were seen in 5 (25%) patients, namely, inadequate anatomical reduction (n = 1), superficial wound infection (n = 1), deep infection (n = 1), subacromial impingement (n = 1), axillary nerve neuropraxia (n = 1), adhesive capsulitis (n = 1) and secondary varus collapse (n = 2). There was no patient who developed avascular necrosis (AVN), non-union, primary or secondary screw perforation, implant failure and vascular injury. Average Constant-Murley Score at final follow up was 84.75 ± 11.6. 85% patients had very good and good functional results. No patient had poor functional results.

**Conclusion:** Proximal humeral locking plate (PHLP) is an excellent implant in Neer's two and three part fractures of the proximal humerus. Complications can be minimized by meticulous surgical technique and proper placement of screws and plate. In case of medial comminution, use of PHILOS with placement of medial support screws and bone grafting should be preferred to prevent varus collapse.

## Key words

Analysis, Proximal humeral locking, Plate fixation, Proximal humerus fracture.

## Introduction

Fractures of the proximal humerus constitute about 4 % of all the fractures and about 26 % of humeral fractures [1]. As the life expectancy is increasing, incidence of these fractures is on rise as a consequence of osteoporosis. Some epidemiological studies show that in people more than 60 years of age, fracture of proximal humerus is more frequent than fracture around hip joint [2]. In elderly patients with poor bone stock these fractures usually result from low velocity indirect trauma while as in younger age group the mechanism is that of high velocity trauma like road traffic accidents [3].

Management of these fractures has been controversial. These fractures have been managed by both non-surgical as well as surgical interventions, each having specific indications [4]. Different surgical methods for reduction and fixation either by closed, minimally invasive or open technique have been used. Bone sutures, circlage wires, smooth and threaded pins, tension band wiring, T plates, semi-tubular plates as an angular blade plates, interlocking nails, proximal humeral locking plates (PHLP), proximal humeral interlocking osteosynthesis (PHILOS) are the different modalities of fixation of proximal humeral fractures [5, 6, 7, 8]. Each modality of fixation has its own merits and demerits. Complications are associated with each modality but are least with locking plates. Locking plates (PHLP and PHILOS) designed to match proximal humeral anatomy act as a rigid fixed angle construct for stable fixation of proximal humeral fractures to allow early rehabilitation without risk of screw loosening and failure as seen with conventional plates and screws [5]. Proximal end of plate has an option for multiple locking screw placements in convergent and divergent manner into the humeral head which gives additional stability [9]. Both PHLP and PHILOS work on same basic principle with difference in number of holes for screw placement [3, 7]. PHILOS has more

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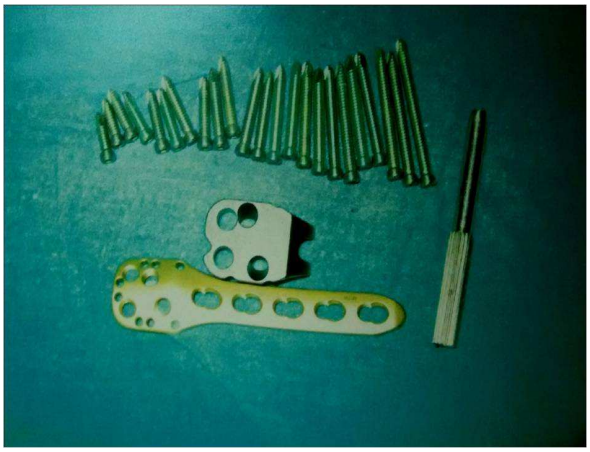
proximal holes which makes it more suitable implant for complex fractures and osteopenic bone. Additionally these plates have holes for suture anchors passed through rotator cuff and soft tissue attached to tuberosities which gives additional stability (**Figure - 1**) [3].

**Figure - 1:** Proximal humeral locking plate having multiple proximal locking options and small holes for anchor sutures.



## Material and methods

This retrospective study was conducted on patients with Neer's two or three part fractures of the proximal humerus managed surgically by PHLP from August 2012 to April 2014. Adult patients above age of 18 years with close or Gustilo type I and II open fractures with minimum postoperative follow up of one year were included in the study. Patients with type III open fractures, pathological fractures, isolated fractures of tuberosities, Neer's four part fractures, presence of fracture dislocation, associated injuries of ipsilateral upper extremity, presence of neurovascular compromise of the involved extremity and fracture more than three week old were excluded. From the Medical Record Section of the hospital 23 patients fulfilled these criteria. Out of these, 20 patients could be traced for follow up.

All the patients had been operated through a standard delto-pectoral approach. The fracture fragments had been meticulously dissected avoiding excessive soft tissue stripping. After reduction of the fragments and provisional k-wire stabilization under fluoroscopic control, PHLP was seated along antero-lateral surface. And plate stabilized with locking screws or cancellous screws with locking heads in the humeral head and locking or cortical screws in the diaphysis. Additional stabilization of the tubercles, if fractured, was achieved with anchor sutures (non-absorbable) placed through holes in the proximal part of the plate and tendinous attachments of the tubercles. Care was taken for anatomical reduction of the fracture. Bone graft had not been used in any of the patients. Shoulder was immobilized in a shoulder immobilizer for 2 to 3 days following which passive and pendulum exercises were started. Active exercises were started around 4 to 6 weeks postoperatively. Resistive strengthening exercises were started only when there was radiological evidence of bone union. In the postoperative period the patients were followed every two weekly with clinical examination and radiographs till evidence of radiological union of the fracture lines. In all the cases final follow up was carried out after one year and the final clinical and functional outcome was evaluated with Constant- Murley Score (CMS). Functional outcome as per CMS is graded as poor (0 - 55), mean (56 – 70), good (71 – 85) and very good (86 – 100) [10]. Besides this previous serial radiographs were evaluated for radiological union and complications (**Figure - 2**, **Figure - 3**, and **Figure - 4**). The data was analysed using statistical software MS (Microsoft) excel and SPSS (Statistical Package for Social Science) version 17 for windows. Data was presented as percentages or mean ± SD (standard deviation) as deemed appropriate for qualitative and quantitative variables respectively.

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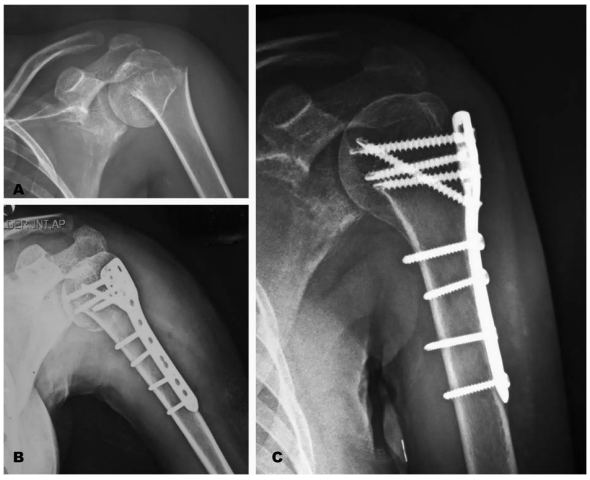
**Figure - 2:** Neer's two part fracture. A) Pre-operative. B) Post-operative. C) Final follow-up radiograph.

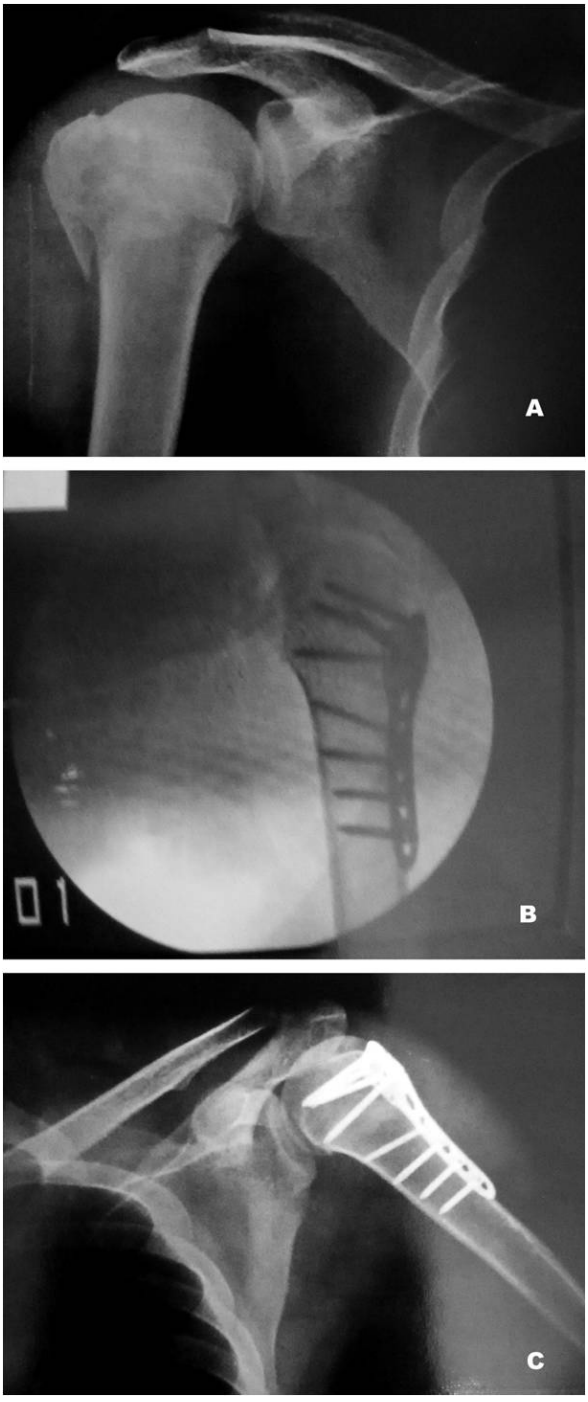



## Results

The age of the patients ranged from 20 to 66 years with an average of 40.6 ±14.4 years. Only five (25%) patients were more than 60 years of age. The male to female ratio was 3: 2. Vehicular road side accident was the most common mode of injury accounting for 65 % of the patients. 25 % patients had fall and 10 % had physical assault as the aetiology. 8 (40%) patients had Neer's two part fracture and 12 (60%) had Neer's three part fracture. Average injury to surgical intervention interval was 6.2 ± 4.3 days with a range of 2 to 20 days. Final follow up of the patients ranged from 13 to 33 months with an average follow up of 23.2 ± 6.1 months.

All the fractures united and time to radiological union ranged from 12 to 20 weeks (Mean = 14 ± 2.5 weeks). Over all there were 8 complications in 5 (25%) patients (**Table - 1**). Average CMS at final follow up was 84.7 with no statistically significant difference (p value = 0.26) between Neer's two and three part fracture groups (**Table - 2**). The final functional outcome was very good in 10 (50%) patients, good in 7 (35%) and mean in 3 (15%) patients. No patient had poor functional outcome.

**Figure - 3:** Neer's three part fracture. A) Pre-operative. B) Post-operative. C) Final follow-up radiograph.




## Discussion

Majority of the proximal humerus fractures are stable and undisplaced and are managed by conservative means [11]. Unstable and displaced fractures (displacement of 1 cm and above or

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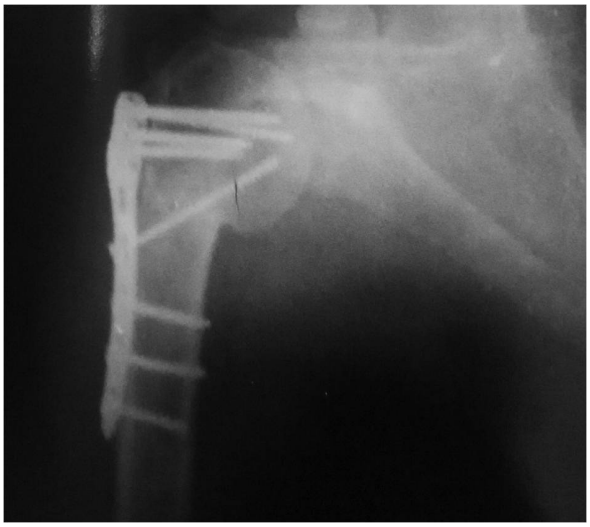
angulation of 45˚ and above of the fracture fragments) require surgical intervention for reduction and stabilization [12, 13]. Different techniques and implants have been used but advent of locking plates has revolutionised the treatment of these fractures [5, 6, 7]. Locking plates forming fixed angle stable construct, gives rigid and stable fixation. This is especially of great value in osteoporotic bones where screw loosening and subsequent implant failure is seen with conventional plates [5, 14]. Stable fixation also aids in early rehabilitation of the shoulder joint [5]. Locking plates pre-contoured to match proximal humeral anatomy with multiple proximal locking screw placement options has made fixation of complex fractures easy and further enhanced the stability. Locking plates do not need periosteal stripping of the bone to seat the plate thus preserving the periosteal blood supply to the fracture fragments [3].

**Figure - 4:** Final follow up radiograph with collapse of the fracture into varus malunion.



Despite these advantages, complications do occur and frequency of complications varies from 10 to 80% in the literature [15]. Complications may be related to inappropriate surgical technique or it may be related to fracture geometry. Those related to surgical technique are preventable and include inadequate fracture reduction, intra-articular screw placement, improper plate placement leading to impingement, excessive soft tissue stripping of the fracture fragments predisposing to avascular necrosis and non-union, loss of reduction in case where tuberosity fragments are not secured by anchor sutures and occasional neurovascular injury. Complications inherent to fracture pattern include inability to achieve anatomical reduction, higher degree of comminution predisposing to avascular necrosis especially in four part fracture dislocations, and medial column comminution predisposing to varus collapse [16]. Besides, patient factors like osteoporosis increases risk for implant failure, varus collapse and secondary intra-articular screw perforation [11, 17].

**Table - 1: Complications.**

| Complications | No. of patients (percentage) |
|---|---|
| Inadequate reduction | 1 (5%) |
| Superficial infection | 1 (5%) |
| Deep infection | 1 (5%) |
| Varus collapse | 2 (10%) |
| Shoulder impingement | 1 (5%) |
| Adhesive capsulitis | 1 (5%) |
| Neurological injury | 1 (5%) |

**Table - 2:** Constant-Murley Score at final follow up.

| Neer's Fracture Type | No. of patients | Mean CMS ± SD (Range) |
|---|---|---|
| Two part | 8 | 88.4±7.1 (78 to 99) |
| Three part | 12 | 82.3±13.2 (58 to 100) |
| Both two and three part | 20 | 84.7±11.6 (58 to 100) |

(CMS: Constant-Murley Score; SD: Standard Deviation)

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Near about 40% complications are due to incorrect surgical technique and the most common one is the intra-articular screw placement [7, 18]. In series by Konrad G, et al. (2010) 14 % patients had intra-operative screw penetration of the humeral articular surface [18]. In our series we had no case of intra-articular screw placement. This complication can be avoided by looking for placement of screws under image intensifier in neutral, internal rotation and external rotation position of the shoulder as well as axillary view after completing fixation of the plate [17, 18]. 14 % patients in series by Miyazaki AN, et al. (2012) had inadequate intra-operative fracture reduction [16]. We had only one case in our series that was fixed in slight varus. Inability to achieve anatomical reduction was due to medial comminution. Higher rate of inadequate reduction in above series can be explained by inclusion of more complex fractures including epiphyseal fractures. Aksu N, et al. (2010) had 4.9% patients with fractures fixed in varus which is comparable to our study [19]. One patient in our series had weakness (Grade 3 power) of shoulder abduction in the follow up and nerve conduction study and electromyography demonstrated axillary nerve injury. It was a neuropraxia and patient had recovered fully with grade 5 power at final follow up. There was no vascular injury in any of our patients during surgical intervention. Geiger EV, et al. (2010) had transiently decreased radial nerve sensations for few months in 7.2 % of their patients [20]. Aggarwal S, et al. (2010) had two cases (3.6%) of axillary nerve palsy which improved within one year in their series [21]. Vascular injury is an extremely rare entity and may result from screw tips impinging axillary artery leading to psudoaneurysm formation [22]. The incidence of subacromial impingement ranges from 0 to 10.3% in the literature [16]. Miyazaki, et al., Schliemann B, et al. (2012) and Geiger EV, et al. had 12.5%, 18.5% and 21.4% patients respectively in their series having subacromial impingement [16, 17, 20]. On the other hand Aksu N, et al. and park J, et al. (2014) had no patient with subacromial impingement in their series [19, 23]. We had one case of impingement and it was due to more cranial placement of the plate. To prevent mechanical impingement the proximal end of the plate should be placed 5 to 8 millimetre distal to tip of greater tubercle [16].

Two patients (10%) developed varus collapse postoperatively. One patient had fixation in slight varus and there was further varus collapse in the follow up and other patient had anatomical reduction and fixation with varus collapse in the follow up. The head shaft angle at final follow up was $105^{o}$ and $110^{o}$ respectively (**Figure - 4**). Both these cases had medial metaphyseal comminution with osteoporosis. Owsley, et al. (2008) demonstrated incidence of varus collapse was 25% and screw cut out 23% in fractures with metaphyseal comminution and primary varus displacement [24]. Miyazaki AN, et al. had done bone grafting in 12.5% of their patients and had varus collapse in only one (1.7%) patient [16]. There is always a varus cantilevering force at the surgical neck of the humerus as a result of rotator cuff abducting the head fragment and pectoralis major and latissimus dorsi muscles adducting the shaft fragment, which explains the need of anatomical reduction of the medial support in these fractures [25]. The concept of medial support screws (MSS) in complex fractures allows better maintenance of reduction [26]. Zhang W, et al. (2014) from their biomechanical study concluded that if there is medial comminution or medial cortex is malreduced, three medial support screws should be placed to reconstruct medial column support [27]. So, lack of medial column support in proximal humeral fractures warrant bone grafting and use of PHILOS with maximum number of MSS to prevent varus

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collapse. PHLP has an option for placement of a single MSS so PHILOS is a preferred implant in fractures with medial column comminution. Fracture collapse or loss of reduction can lead to secondary perforation of screws into the joint [17]. We did not have any case of secondary perforation of screws in our series. Risk of perforation is high if screws tips are placed in subchondral bone and or articular surface has been drilled before screw placement [15]. Jost B, et al. (2012) describes glenoid destruction by perforating screws as the most devastating complication which limits the treatment options [28].

There was one (5%) patient who developed superficial infection and was managed by dressings and extended course of antibiotics. One deep infection developed in a patient with Gustilo Type 2 open fracture. Patient underwent through debridement and lavage and extended course of antibiotics. Infection subsided but the patient developed serous discharging sinus later on and the implant was removed after fracture union at five months. One patient developed adhesive capsulitis but the final functional outcome was mean. There was no case of avascular necrosis (AVN) or non-union in our retrospective series. This can be explained by the fact that we had excluded Neer's four part fractures and fracture dislocations in our study and meticulous dissection avoiding soft tissue stripping of the fracture fragments during surgery. Spross C, et al. (2012) in their study on Neer's 4 part fractures managed by PHILOS had 54.5% patients complicated by AVN [29]. Schliemann B, et al. in their series on 3 and 4 part fractures had AVN in 29.6% patients [17]. While as Park J, et al. had no case of AVN in their series on 2 and 3 part fractures [23]. All fractures united at a mean of 3.5 months and in a similar series by Park J et al mean time to union was 3.2 months [23].

The mean CMS in our series at final follow up was 84.75 (range: 58 to 100) and that of Park J, et al. who used PHILOS by minimally invasive technique was 82.7 (range: 66 to 92) which is statistically comparable (p-value = 0.49) [23]. 17 (85%) patients in our study had very good and good final functional outcome. No patient had poor outcome in our series. Park J et al had very good and good functional outcome in 90.5% patients with no patient having poor results ($\chi^2$ = 0.003; p-value = 0.477) [23].

## Conclusion

Open reduction and internal fixation of Neer's two and three part fractures with proximal humeral locking plates (PHLP) have excellent results. Meticulous surgical technique, anatomical reduction of the fracture, proper placement of the plate with fixation by locking screws of appropriate length, securing fractured tubercle fragments with non-absorbable anchor sutures and early rehabilitation are key to avoid complications. In cases where anatomical reduction of medial calcar is not possible due to comminution of the medial metaphyseal region, PHILOS with placement of more than one medial support screws (MSS) and bone grafting should be preferred in place of PHLP to prevent varus collapse.

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