

Fractures of the proximal humerus in children and adolescents

Joshi RR^{a,d}, Narang S^{b,d}, Sundararaj GD^{c,d}

ABSTRACT:

Background: In most children proximal humeral fractures are treated non-operatively with generally good results. The aim of the study was to evaluate the clinical outcome of closed/open reduction in children with severely displaced proximal humeral fractures. **Materials and Methods:** The charts of 15 patients (8 girls and 7 boys; mean age: 9.4 years) with proximal humeral fractures who were managed at our institution were reviewed from October 2011 to December 2013. **Results:** There were 7 metaphyseal fractures and 8 physal injuries which were angulated according to Neer-Horowitz score as grade II (n=2), grade III(n=4) and grade IV(n=9). Associated lesions comprised open fracture with head trauma in a 2 year old female child which was operated on primarily and the 14 others by secondary intention. All patients were treated surgically with either closed (n = 5) or open (n=10) reduction and internal fixation with Kirschner wire or titanium elastic nails (TENs). They were assessed for clinical and radiological healing at a mean follow up of 1.25 years ranging from 0.5 to 2.0 years. **Conclusion:** Surgical option is indicated for severely displaced and unstable fractures in older children and adolescents. In addition to the periosteum, long head of the biceps, deltoid muscle, and bone fragments in combination can prevent fracture reduction.

Key words: Proximal humerus fracture, Children, Open reduction, Operative.

Introduction

Proximal humeral fractures account for only 1% of all fractures in children and 3 to 6% of all epiphyseal injuries.¹ The majority of proximal humeral fractures are either undisplaced or minimally displaced (Neer-Horowitz grade I-II) and can be managed non-operatively with a satisfactory outcome.^{2,3} However, in cases of severe humeral fractures with significant bone displacement (Neer-Horowitz grade III-IV), especially in teenagers, non-operative treatment is controversial. An important concern of surgeons while dealing with paediatric proximal humeral fractures is the growth of the bone and the resulting remodelling potential. In

fact, approximately 80% of the longitudinal growth of the humerus comes from the proximal humeral physis.⁴ The concern for disruption of the bone growth and remodelling leads surgeons to choose non-operative treatment regardless of the degree of displacement, angulation, rotation or translation. However, immobilization by a cast is lengthy, uncomfortable and hard for children to tolerate. The residual deformities after non-operative treatment, such as upper limb length discrepancy, humerus varus or humerus valgus, can lead to cosmetic problems due to the decreasing ability of remodelling in older children.⁵ Therefore, some surgeons in recent years have recommended closed or open reduction and internal fixation for proximal humerus fractures in children, especially in teenagers.^{6,7}

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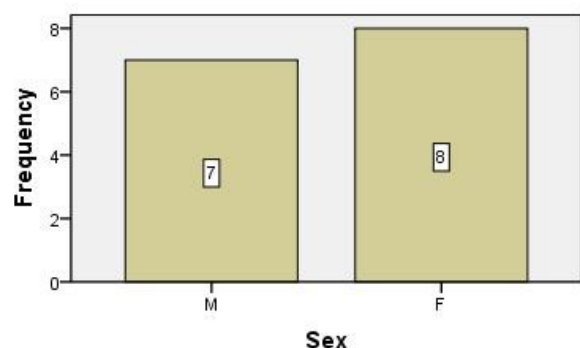


Fig 1: Sex distribution

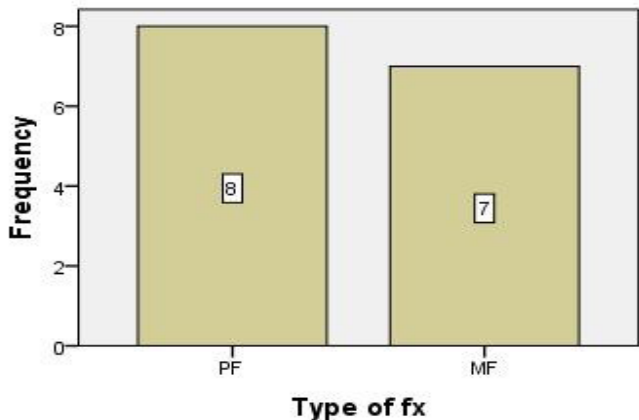


Fig 2: Type of Fxs (MF: Metaphyseal fracture; PF: Physeal fractures)

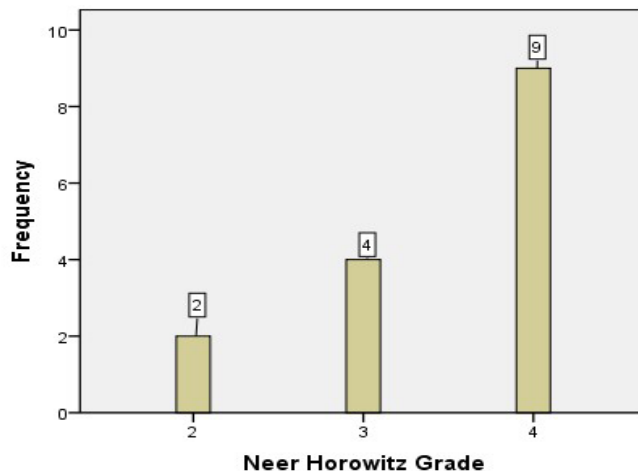


Fig 4: Neer - Horowitz grade

The methods of internal fracture fixation include percutaneous K-wires, staples, screws or plates.⁸⁻¹⁰ However, complications such as pin tract infection, pin migration, osteomyelitis and loss of reduction have been reported using these modes of fracture fixation.⁸⁻¹¹

Methods:

This was a retrospective study of patients treated for proximal humeral fractures at the Department of Orthopedic Surgery, Lumbini Medical College and Teaching Hospital, Palpa, from October 2011 to December 2013. There were 15 patients, 8 girls and 7 boys (Fig 1); their mean age was 9.4 years. All patients were skeletally immature as defined by open proximal humeral growth plates on the injured side at the time of injury based on plain radiographs. The most common cause was tumbling during play or sports, followed by traffic accidents. None of the fractures was pathological. There were no associated neurovascular injuries in the arms. There were 7 metaphyseal fractures and 8 epiphyseal fractures (two cases of type I and six cases of type II according to the Salter-Harris classification) (Fig 2 & 3). According to Neer-Horowitz classification, there were two cases of type 2, four were type 3 and nine were type 4 (Fig 4). There was a 2 years girl (Fig 8) with an open proximal humerus fracture (Gustilo type IIIA) due to fall from height and was accompanied by head injury. Indications for surgery in all the patients were irreducibility in nine

cases and re-displacement in six. All the children were treated with either closed or open reduction with K wires or TENs for severely displaced proximal humeral fractures. Open reduction via deltopectoral approach & internal fixation with K wires was required in nine cases & one case (Fig 8; 9A,B) with an open fracture (Gustilo IIIA) was operated emergently with debridement & k wire fixation. The remaining three patients had closed reduction internal fixation with K wires. Two patients were managed by closed reduction and TENs were inserted by retrograde route (Fig 11).

Outcome assessment:

We undertook a retrospective review to evaluate outcomes including, clinical results, complications related to treatment and radiological assessments. Patients were assessed clinically and radiographically at 6 weeks, 3 months, 6 months and annually and were examined for fracture healing, angulation at the fracture site, premature closure of the growth plate and shortening of the humerus. Radiological evaluations were carried out using anteriorposterior and lateral views of the humerus. We adjudged the result excellent if shoulder function was similar to the normal side, good if the function was normal with radiologic imperfections and fair when both were abnormal. The potential complications related to treatment include neurovascular injury,

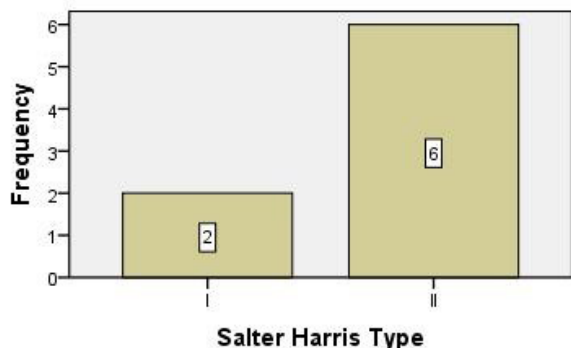


Fig 3: Salter Harris Type

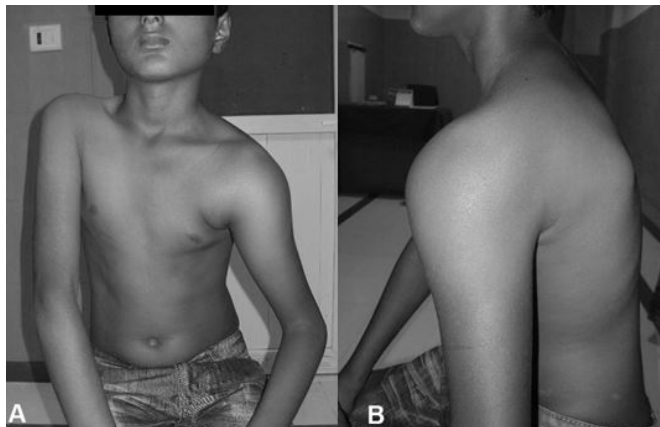


Fig 5: Clinical picture of 11 years old boy with left proximal humerus fracture

Table 1: Type of Implants

Implants	n	Percent
K wires	13	86.7
ESIN	2	13.3
Total	15	100.0

deep infection, pin tract infection, pin migration, loss of reduction and skin irritation. The evaluation of the clinical outcomes was both objective and subjective.

Results :

Patient presented to us at mean of 2 days following injury & surgery was carried out at a mean of 4 days after their initial injury. A total of 5 fractures were reduced by closed reduction, while 10 patients underwent open reduction (Table 2), including one case with an open fractures (Fig 8) ; in seven cases it was found that the fracture site was interposed with periosteum, and in the other two cases the fracture site was interposed with the long head of the biceps & bone fragment. K-wire fixation was most commonly used (85.7%), followed by retrograde elastic stable intramedullary nailing (14.28 %)(Table 1). The surgical approach utilized included a formal delto-pectoral approach in the majority of cases, in three cases, an oblique incision was made over the metaphysis anterolaterally in order to obtain access to an interposed

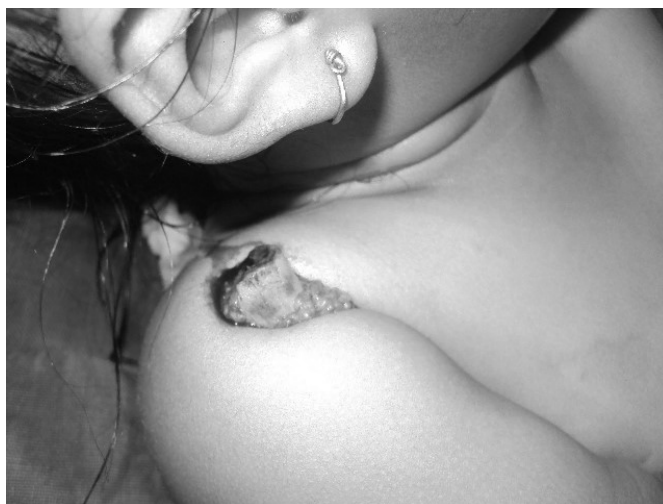


Figure 8: 2 years old child with open proximal right humerus fracture sustained from a fall while playing

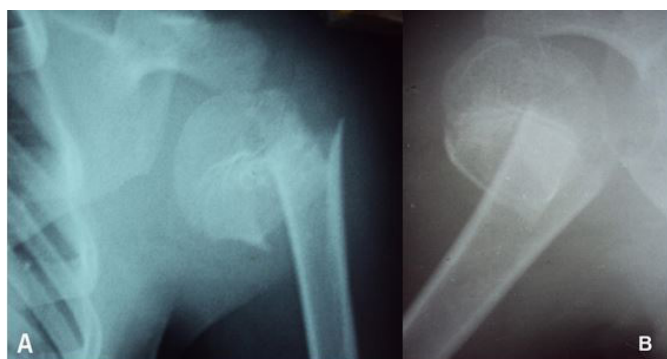


Fig 6(A & B): Pre-operative anteroposterior (AP) radiograph, Salter-Harris type II fracture of the proximal humerus fracture

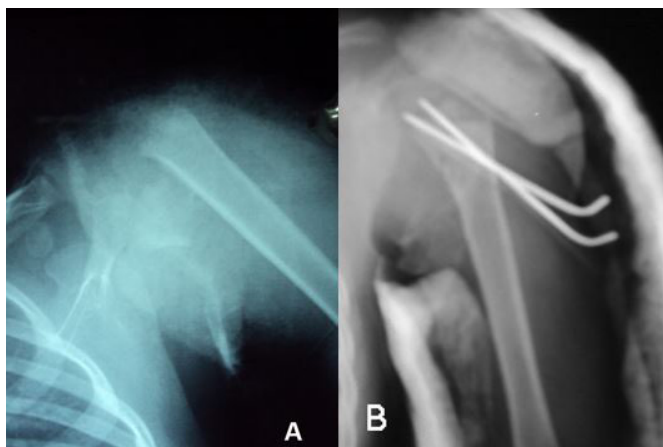


Figure: 9(A) Injury film; (B) Immediate Post op radiographs after K-wire fixation

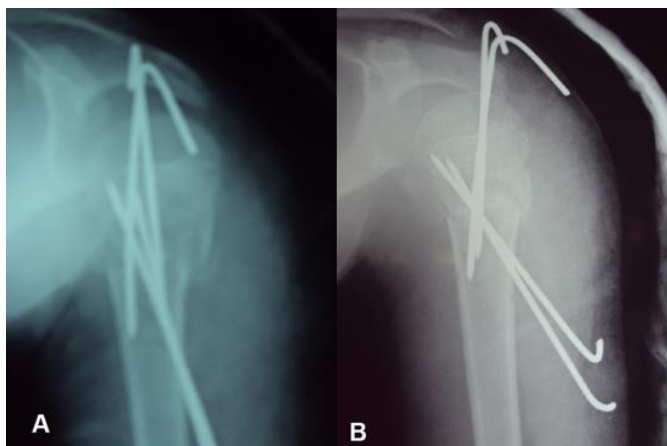


Fig 7(A & B): Immediate Postoperative radiographs after K-wire fixation

bony fragment. Postoperatively, all patients who were treated with K wire fixation were immobilised using a U splint until radiological union, at which time pins were removed. The follow up period averaged 1.25 years (range = 0.5 to 2.0 years). Radiological healing duration averaged 34 days (range = 28 - 40 days). At follow up, excellent and good results (Table 3) were achieved in all the patients and had non-painful shoulder range of motion and normal rotator cuff strength (comparable to the opposite side) and returned to activities at a mean of 2.3. months from the time of the surgery. Implant removal was performed after a duration of 6 to 10 weeks for K wires and after 6 months for TENs fixation. One girl developed marked keloids and two patients had minor valgus deformity with of no clinical significance. Neither physcal arrest nor

Table 2: Treatment (CRIF: Closed reduction internal fixation; ORIF: Open reduction internal fixation)

Treatment	n	Percent
CRIF	5	33.3
ORIF	10	66.7
Total	15	100.0

Table 3: Outcome

Results	n	Percent
Excellent	8	53.3
Good	7	46.7
Total	15	100.0

avascular necrosis was observed. Major complications, such as deep infections, neurovascular injuries, loss of reduction and nail migration, were not observed. Skin irritation relating to prominent hardware occurred in three cases, and resolved following implant removal.

Discussion:

Traditionally, proximal humerus fractures in skeletally immature patients have been treated non-operatively due to the tremendous potential for remodeling and the wide functional arc of motion of the shoulder. As a result, even significantly angulated and displaced fractures have achieved union in positions that have allowed for normal or near-normal functional outcome. In children up to 10 years of age, axial malalignment of the proximal humerus of as much as 60° in varus, anteversion, or retroversion can be corrected by remod-



Fig 12: (A&B) months followup with excellent function



Fig 10: (A) 3 months followup showing good function with complete union(B)

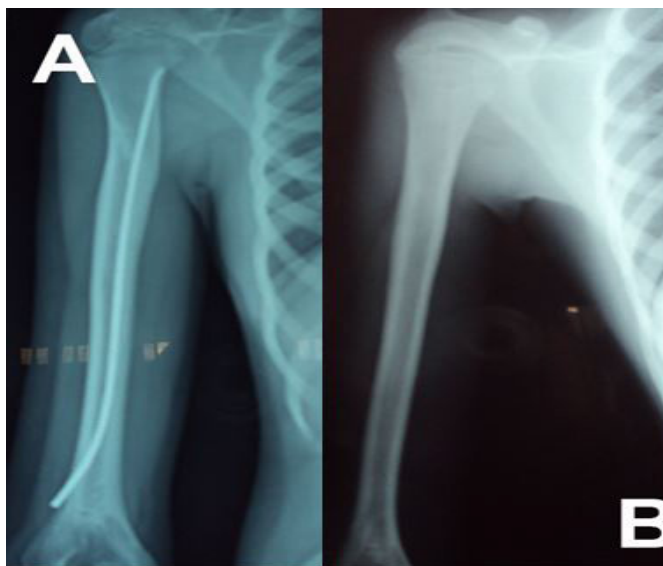


Fig 13: (A) 7 months post-operative AP radiographs showing complete healing prior to flexible nail removal; (B) After implant removal

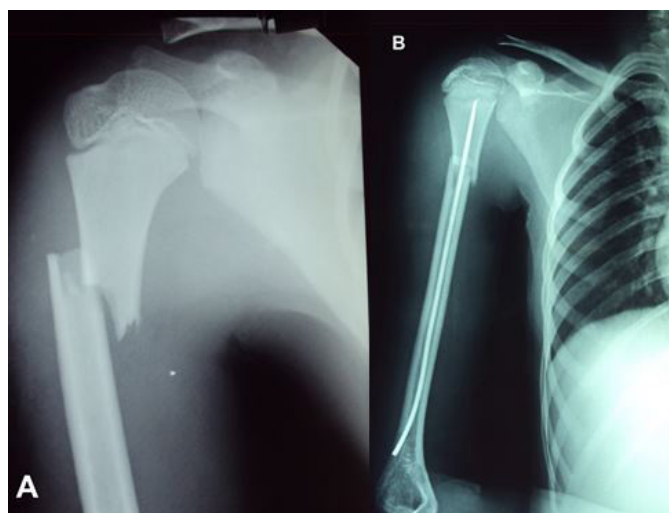


Fig 11: (A)13 years old boy with proximal metadiaphyseal humerus fracture.(B) Post op reduction radiographs with a single retrograde TEN.

eling; however, beyond 10 years of age, the remodeling potential is not as high and correction can be expected only with axial deformities of up to 20–30°. Pahlavan et al.,¹⁵ in a systematic review of 569 proximal humerus fractures treated in the literature from 1960 to 2010, found that patients below the age of 10 and above the age of 13 years should be treated as distinct patient populations. Through a review of patient outcomes in their review, the authors found that children less than 10 years of age should be treated non-operatively due to their tremendous remodeling potential, whereas patients above the age of 13 years are candidates for open reduction and fixation due to a much more limited remodeling potential. Furthermore, Dameron and Reibel evaluated 46 skeletally immature patients with proximal humerus fractures and found that, in their patients above the age of 14 years, poor outcomes were noted due to loss of reduction.⁵ Kohler and Trillaud¹³ reported their proximal humeral fracture experience and noted that, in their subset of older patients, operative intervention was warranted, as irreducible fractures could not remodel. In regards to severe displacement, Neer and Horwitz found that patients with severe displace-

ment (greater than 2/3rds of the humeral shaft) had persistent deformity and arm shortening compared to the contralateral side.² In addition, Schwendenwein et al.¹⁴ examined 16 patients with significantly displaced proximal humeral fractures who underwent operative intervention with excellent results, recommending operative treatment in displaced fractures. Due to the results of studies such as those mentioned above, operative indications for proximal humerus fractures are expanding, particularly in adolescent patients with displaced fractures.^{2,17} As in our nine patients with age of ten or more, operative intervention can lead to good results. With an understanding of the indications for operative intervention (i.e., increased age, displacement, and angulation) which can lead to excellent results. Within our cohort of nine patients, all patients failed attempts at closed reduction either in the emergency room and/or the operating room. Not surprisingly, at the time of open reduction, all of them were found to have anatomical structures blocking reduction. Traditionally, the long head of the biceps and/or periosteum has been reported to prevent the reduction of proximal humerus fractures in a closed fashion.^{2,12,14} Bahrs et al.⁷ examined 43 patients with proximal humerus fractures (33 treated operatively), in which 17 could not be closed reduced under general anesthesia. In seven cases, the biceps was entrapped, and in two cases, periosteum was entrapped. Yet, in our study, we found not only the periosteum and long head of the biceps entrapped within the fracture site, but also deltoid muscle, as well as bony fragment. As a result, it would be quite difficult to achieve a reduction via closed means with these multiple structures within the fracture site. A myriad of open

approaches can be utilized, although formal delto-pectoral approaches were most commonly used. With knowledge of the appropriate indications for operative treatment and the need for a formal open approach to adequately address all interposed structures, it is critical to understand the different fixation methods at the disposal of the treating surgeon. In our series, 85.7 % of patients underwent K-wire fixation, 14.28 % with flexible nails. All of our patients achieved excellent functional and radiographic outcomes, regardless of the implant utilized. Burgos-Flores et al.⁶ noted excellent results in 22 patients with displaced proximal humerus fractures treated with K-wire fixation at a mean of 6.8 years after surgery. Disadvantages of K-wire fixation include non-rigid fixation necessitating cumbersome post-operative immobilization, pin tract infections, and the need for secondary procedures to remove hardware. In addition, there is a risk for hardware breakage. In conclusion, operative treatment of proximal humerus fractures, particularly in adolescents with severe displacement/angulation and failure of closed methods, is increasingly being seen as an acceptable modality of management. In addition to the long head of the biceps, periosteum, deltoid muscle, and bone fragments in combination can prevent fracture reduction. Surgeon preference and skill should dictate implant choice, as patients achieved excellent functional and radiographic outcomes at the final follow-up with the use of K-wires, flexible nails, or cannulated screws. The risk of physeal damage with these implants is low. Further randomized, controlled studies are necessary so as to examine the operative treatment of proximal humeral fractures in the adolescent population.

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