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Original Research Article

A PROSPECTIVE OBSERVATIONAL STUDY OF PEDIATRIC PROXIMAL PHALANX FRACTURES: EPIDEMIOLOGY, CLINICAL FEATURES, MANAGEMENT, AND OUTCOMES

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ABSTRACT

Background: Proximal phalanx fractures are the most frequent hand fractures in children. Although most injuries are treated nonoperatively, outcomes vary according to fracture pattern, anatomical location, degree of displacement, and the presence of associated soft tissue injury. The objective is to evaluate the clinical profile, management patterns, and functional and radiological outcomes of proximal phalanx fractures in children aged 12 years or younger.

Materials and Methods: This prospective study was conducted from January 2024 to January 2025 and included 24 children with proximal phalanx fractures. Data were collected on age, sex, mechanism of injury, fracture location and type, associated injuries, treatment modality, and follow-up outcomes. Pain was assessed using the Visual Analog Scale [VAS], functional outcome was evaluated by range of motion, and residual deformity was assessed on follow-up radiographs.

Results: The study included 24 children, comprising 16 males and 8 females, with a mean age of 9 years. Sports-related trauma was the most common mechanism of injury, accounting for 58.3% of cases. The base of the proximal phalanx was the most frequently affected site [50.0%]. Conservative management with a volar slab was successful in 14 patients, whereas open reduction was required in 1 patient. At a mean follow-up of 9 months, 91.7% of patients were pain-free. Residual deformity was noted in 2 patients. Stiffness and restricted range of motion were primarily observed in children with associated soft tissue injury or extensor tendon involvement.

Conclusion: Proximal phalanx fractures in children generally have favorable outcomes with conservative treatment. However, displaced fractures and injuries associated with soft tissue damage may require surgical intervention. Adherence to physiotherapy appears to play an important role in optimizing functional recovery.

Keywords: children; proximal phalanx fracture; pediatric hand fractures; conservative management; functional outcome; range of motion; soft tissue injury.

INTRODUCTION

Hand fractures are among the most common skeletal injuries in the pediatric age group and account for a considerable proportion of upper-limb trauma in children. Within this broad category, phalangeal fractures are especially frequent, and fractures of the proximal phalanx are among the most commonly

encountered because of their anatomical exposure and susceptibility to direct trauma during play, falls, and sports-related activities.[1-3] The growing participation of children in outdoor games and recreational sports, combined with immature judgment and limited awareness of danger, increases the likelihood of hand injuries in this age group.[4,5]

The epidemiological profile of these fractures consistently demonstrates a male predominance, which is generally attributed to greater involvement in vigorous physical activity and risk-prone behavior. The dominant hand is often affected because of its frequent use in grasping, writing, sports, and reflexive protection during falls. The mechanism of injury is variable and includes sports trauma, falls, crush injuries, and door-trap injuries. Although many pediatric proximal phalanx fractures appear simple at initial presentation, their clinical relevance is substantial because untreated or inadequately managed injuries can result in malalignment, rotational deformity, stiffness, and persistent functional impairment.[1,2]

Pediatric proximal phalanx fractures differ from adult fractures because of the presence of open growth plates, a thick periosteum, greater remodeling potential, and faster healing characteristics of immature bone. These features often support successful conservative management, particularly in stable and minimally displaced fractures.[1,6] However, remodeling alone cannot reliably correct rotational deformity, marked displacement, or intra-articular incongruity. Therefore, careful clinical examination and appropriate radiographic assessment are essential at the time of presentation. Fractures should be classified according to site, pattern, displacement, angulation, joint involvement, and associated soft tissue or tendon injuries, as these parameters directly influence both treatment strategy and prognosis.[2,3,7]

Management of pediatric proximal phalanx fractures is guided primarily by fracture stability, alignment, and associated soft tissue damage. Stable, undisplaced, or minimally displaced fractures are generally treated effectively with immobilization followed by supervised mobilization, whereas unstable, displaced, or rotational fractures may require reduction and, in selected cases, surgical fixation.[2,3,6,7] Since the principal goal of treatment is restoration of pain-free motion and normal hand function rather than union alone, early diagnosis, appropriate intervention, and adherence to physiotherapy are crucial for achieving favorable outcomes. The aim of the present study was to evaluate the epidemiological profile, clinical characteristics, treatment modalities, and functional and radiological outcomes of pediatric proximal phalanx fractures in children aged 12 years or younger.

MATERIALS AND METHODS

Study design and setting: This prospective observational study was carried out at ESIC Medical College and Hospital, Sanathnagar, Hyderabad, over a 13-month period from January 2024 to January 2025. The study was designed to evaluate the clinical profile, fracture characteristics, treatment patterns, and short-term functional and radiological outcomes of proximal phalanx fractures in children.

Study population: The study population comprised children aged 12 years or younger who presented to the hospital with suspected finger trauma and were subsequently diagnosed with proximal phalanx fracture on radiological examination. All eligible patients were assessed clinically and enrolled consecutively during the study period.

Inclusion criteria

Children aged 12 years or younger with radiologically confirmed fracture of the proximal phalanx were included in the study.

Exclusion criteria

Children with pathological fractures, underlying systemic bone disease, congenital skeletal abnormalities, or inadequate follow-up were excluded. Patients whose records were incomplete or who were lost to follow-up before outcome assessment were also not considered for final analysis.

Sample size: A total of 24 children who fulfilled the eligibility criteria were included in the study.

Clinical and radiological assessment: At presentation, each patient underwent detailed clinical evaluation and radiographic assessment. Demographic and clinical variables were documented in a structured proforma. These included age, sex, hand dominance, side involved, and mechanism of injury. Standard radiographs of the affected hand were obtained in anteroposterior, lateral, and oblique views to confirm the diagnosis and define fracture characteristics.

Fracture characteristics: Fractures were categorized according to anatomical location within the proximal phalanx, including base, shaft, and head injuries. Additional fracture-related variables such as displacement, intra-articular extension, fracture configuration, and rotational malalignment were recorded. Associated injuries, including soft tissue trauma, extensor tendon injury, and other concomitant hand injuries, were carefully noted, as these factors were considered relevant to treatment selection and outcome.

Treatment protocol: Management was planned according to fracture stability, degree of displacement, and the presence of associated injuries. Stable and minimally displaced fractures were managed conservatively, primarily with immobilization using a volar slab. Surgical intervention was reserved for fractures with significant displacement, instability, rotational deformity, intra-articular involvement, or associated soft tissue injury requiring operative management. The treatment modality adopted for each patient,

along with the duration of immobilization, was recorded systematically.

Follow-up and outcome assessment: All patients were followed up clinically and radiologically at regular intervals, with formal outcome evaluation performed at 6 months and 9 months. Pain assessment was carried out using the Visual Analog Scale [VAS]. Functional outcome was evaluated by assessing active range of motion of the affected finger joints and comparing it with the expected age-appropriate movement. Residual deformity, fracture alignment, and evidence of healing were assessed on follow-up radiographs.

Outcome measures: The primary outcome measures included pain status, restoration of range of motion, and radiological alignment at follow-up. Secondary observations included the presence of stiffness, malunion, persistent limitation of movement, and residual deformity. Final outcome was interpreted based on the combined assessment of pain relief, functional recovery, and radiological healing.

Data collection: All clinical, radiological, treatment, and follow-up details were entered into a structured case record form and maintained throughout the study period for uniform documentation and analysis.

Ethical considerations: The study was conducted after obtaining approval from the Institutional Ethics Committee of ESIC Medical College and Hospital, Sanathnagar, Hyderabad. Informed written consent was obtained from parents or legal guardians before enrolment, and patient confidentiality was maintained throughout the study.

RESULTS

A total of 24 children with proximal phalanx fractures were included in the final analysis. The cohort showed a male predominance, with 16 males [66.7%] and 8 females [33.3%], and the mean age of the study population was 9 years (range, 4-12 years). Sports-related trauma was the leading mechanism of injury, accounting for 14 cases [58.3%], followed by falls in 7 cases [29.2%] and door-crush injuries in 3 cases [12.5%]. Blunt trauma was observed in 17 patients [70.8%], whereas 7 patients [29.2%] presented with compound injuries. The right hand was involved more frequently than the left hand [62.5% vs 37.5%]. With respect to digit distribution, the index finger and little finger were the most commonly affected digits, with 7 cases each [29.2%], followed by the thumb in 4 cases [16.7%], and the middle and ring fingers in 3 cases each [12.5%] [Table 1 and 2].

Table 1: Baseline demographic profile of study participants [n = 24]

Variable	n	%
Male	16	66.7
Female	8	33.3
Mean age, years	9	-
Age range, years	4-12	-
Right hand involved	15	62.5
Left hand involved	9	37.5

Table 2: Mechanism of injury and digit distribution [n = 24]

Variable	n	%
Sports injury	14	58.3
Fall	7	29.2
Door-crush injury	3	12.5
Blunt trauma	17	70.8
Compound injury	7	29.2
Thumb	4	16.7
Index finger	7	29.2
Middle finger	3	12.5
Ring finger	3	12.5
Little finger	7	29.2

Radiographic evaluation demonstrated that fractures at the base of the proximal phalanx were the most frequent, occurring in 12 patients [50.0%], followed by shaft fractures in 8 [33.3%], head fractures in 3 [12.5%], and neck fracture in 1 patient [4.2%]. Four fractures [16.7%] had intra-articular extension, 7 [29.2%] were displaced, 14 [58.3%] were undisplaced, 3 [12.5%] were comminuted, and 3 [12.5%] showed rotational deformity. Associated injuries were documented in 7 patients [29.2%], including soft tissue injury in 4 [16.7%] and extensor tendon injury in 3 [12.5%]. These findings indicate that although most fractures were closed and stable, a clinically relevant subset was complicated by displacement or associated soft tissue involvement [Table 3].

Table 3: Fracture characteristics and associated injuries [n = 24]

Characteristic	n	%
Base of proximal phalanx	12	50.0
Shaft of proximal phalanx	8	33.3
Head of proximal phalanx	3	12.5
Neck of proximal phalanx	1	4.2
Intra-articular fracture	4	16.7
Displaced fracture	7	29.2
Undisplaced fracture	14	58.3
Comminuted fracture	3	12.5
Rotational deformity	3	12.5
Any associated injury	7	29.2
Soft tissue injury	4	16.7
Extensor tendon injury	3	12.5

Most children were managed nonoperatively. Volar slab immobilization was the most commonly used modality and was applied in 14 patients [58.3%]. Fracture molding with skin suturing was performed in 7 patients [29.2%], with extensor tendon repair added in 3 of these cases. Closed reduction, LAST splint application, and open reduction with K-wire fixation were each required in 1 patient [4.2%]. All patients underwent 3 weeks of immobilization followed by physiotherapy, although compliance varied with age and cooperation [Table 4].

Table 4: Treatment modalities used in the study cohort [n = 24]

Treatment modality	n	%
Volar slab immobilization	14	58.3
Closed reduction	1	4.2
LAST splint	1	4.2
Fracture molding with skin suturing	7	29.2
Open reduction with K-wire fixation	1	4.2

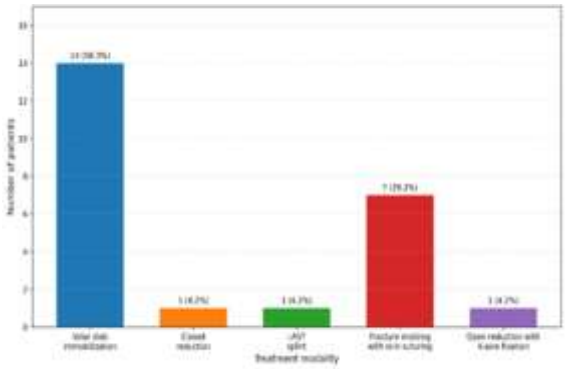

Figure 1: Treatment Modalities Used in the Study Cohort

At a mean follow-up of 9 months, clinical and radiological outcomes were favorable in most patients. Twenty-two children [91.7%] were pain-free, while 2 [8.3%] reported only mild residual pain with a VAS score of 2. Residual deformity was noted in 2 patients [8.3%], both of whom had associated injuries. Stiffness of the proximal interphalangeal joint was observed in 2 patients [8.3%], but improved with physiotherapy. Restricted range of motion was documented in 2 patients [8.3%], and both had concomitant extensor tendon and soft tissue injuries. Radiological union was achieved in all 24 fractures [100.0%], with malunion observed in 1 patient [4.2%]. No patient required surgical reintervention during follow-up. Overall, functional recovery was excellent in the majority of children, whereas adverse outcomes were concentrated in those with more complex associated injuries [Table 5].

Table 5: Follow-up outcomes at 9 months [n = 24]

Outcome	n	%
Pain-free	22	91.7
Mild pain [VAS score 2]	2	8.3
Residual deformity	2	8.3
Joint stiffness [improved with physiotherapy]	2	8.3
Restricted range of motion	2	8.3
Radiological union	24	100.0
Malunion	1	4.2
Surgical reintervention	0	0.0

Case Scenarios

Figure 2: Case 1: 9-year-old male with sports-related oblique fracture of the proximal phalanx head of the right little finger, managed with volar slab. No deformity, full range of motion on follow-up.

Figure 3: Case 2: 5-year-old male with a fall-induced oblique fracture of the PPx base to shaft of the left ring finger, treated with volar slab. Full recovery without deformity.

Figure 4: Case 3: 11-year-old male with a displaced fracture of the PPx base of the left little finger and rotational deformity. Managed with LAST. No deformity at 6 months follow-up.

Figure 5: Case 4: 6-year-old male with displaced PPx fracture of the left thumb. Treated with K-wire and SS wire. Union seen on x-ray but restricted IPJ motion. Ongoing physiotherapy.

Figure 6: Case 5: 8-year-old male with crush amputation of the left mid finger shaft and extensor injury. Underwent open reduction and extensor tendon repair. Malunion with restricted motion noted on follow-up.

DISCUSSION

The present study demonstrates that pediatric proximal phalanx fractures occurred predominantly in boys and were most often related to sports injuries, reflecting the established epidemiological pattern of hand fractures in children. This distribution is consistent with contemporary pediatric fracture literature, which shows that hand and phalangeal injuries are particularly frequent in active school-aged children and adolescents, with higher exposure among boys because of greater participation in outdoor play, contact activities, and recreational sports.[7,9] The predominance of right-sided injuries observed in our series may similarly be explained by the greater use of the dominant hand during play and reflexive protective movements at the time of trauma.[7,9]

In the present cohort, the base of the proximal phalanx was the most commonly involved site. This finding is in agreement with recent reports emphasizing that base fractures form an important subgroup of pediatric phalangeal injuries and often present with varying degrees of angulation, displacement, or rotational malalignment.[4,8,10] These fractures deserve close attention because even though children have substantial remodeling potential, correction of rotational deformity and restoration of joint congruity cannot be assumed in all cases.[14] The anatomical relationship of the proximal phalanx to the metacarpophalangeal joint and surrounding soft tissues also makes appropriate early assessment particularly important.

A major finding of this study is that most fractures achieved favorable outcomes with conservative treatment, especially volar slab immobilization followed by mobilization and physiotherapy. This observation supports the current evidence that stable or minimally displaced pediatric phalangeal fractures can often be managed successfully without operative fixation.[1,2,5,7,13] Recent work has also shown that less invasive strategies, including splinting, buddy taping, and structured conservative protocols, can produce satisfactory healing and functional recovery in selected children.[2,5,6,10,11,13] The high proportion of

pain-free patients and universal radiological union in our study further reinforce the effectiveness of nonoperative treatment when fracture stability is maintained.

However, the results also indicate that displaced fractures and those associated with soft tissue or extensor tendon injury had a less favorable functional course. The patients who developed stiffness, restricted range of motion, deformity, or malunion belonged largely to this subgroup. This pattern is clinically important and aligns with prior studies showing that fracture displacement, instability, tendon involvement, and more complex injury morphology are associated with a greater likelihood of operative treatment and a higher risk of residual functional impairment.[4,6,8,12,14,15] Surgical intervention was required in only one patient in the present series, and the outcome was satisfactory, which is consistent with reports that appropriately selected fixation methods, including K-wire stabilization, can provide good results in unstable or irreducible fractures.[6,8,10,12,15]

Another clinically relevant observation from our study was the influence of physiotherapy compliance on recovery of motion. Although most children recovered well, residual stiffness was seen in a few patients, particularly those with associated injuries. This finding supports the broader pediatric hand-fracture literature, which emphasizes that successful management depends not only on fracture union but also on timely rehabilitation and restoration of motion after immobilization.[1,5,7,14] Younger children may have difficulty cooperating fully with exercises, which can delay functional improvement despite satisfactory radiological healing.

The present study has certain limitations, including its small sample size and single-center design, which may restrict the generalizability of the findings. Nevertheless, it provides useful clinical insight into the epidemiology, treatment patterns, and short-term outcomes of pediatric proximal phalanx fractures in routine practice. Overall, the findings support an individualized treatment approach in which stable fractures are managed conservatively, while displaced fractures and those with associated soft tissue injury are monitored carefully and treated more aggressively when indicated.

CONCLUSION

Pediatric proximal phalanx fractures are common injuries and, in most children, can be managed successfully with conservative treatment, producing satisfactory clinical, functional, and radiological outcomes. The overall prognosis is favorable when fractures are identified early and treated appropriately. However, markedly displaced fractures, rotational deformities, intra-articular involvement, and fractures associated with soft tissue or extensor tendon injury require closer evaluation and, in selected cases, surgical intervention. Careful follow-up remains important to detect residual deformity, stiffness, or malunion at an early stage. In addition, adherence to immobilization and physiotherapy plays a decisive role in restoring range of motion and achieving optimal functional recovery. Timely management combined with structured rehabilitation is therefore essential for ensuring the best outcome in pediatric proximal phalanx fractures.

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