

# Pediatric Subtrochanteric Fracture Treated with Adult Proximal Humerus Locking Plate: A Case Series and Literature Review

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## Abstract

**Background:** A variety of options including titanium elastic nails (TENS) and locking plates (LPs) are available for the internal fixation of subtrochanteric fractures (STFs). However, the preferred treatment option among children and adolescents is still controversial.

**Methods:** We report four cases of STFs in school-aged pediatric patients, treated with an adult proximal humerus LP.

**Results:** Based on the Flynn scoring system at the last follow-up visit, all patients exhibited excellent clinical outcomes, along with satisfactory radiological outcomes based on the Beatty scoring system. There were no complications.

**Conclusion:** Our findings suggest the efficacy of using adult proximal humerus LPs in treating pediatric STFs. The advantage of these plates lies in their ability to accommodate many screws at appropriate positions and angles without damaging the physis. This approach holds promise for the management of pediatric STFs.

**Keywords:** Femoral Fractures; Proximal Femoral Fractures; Hip Fractures; Fracture Fixation; Internal Fracture Fixation

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## Background

Subtrochanteric fractures (STFs) of femur account for a scarce proportion of femoral fractures in children, constituting 4%-17% of such cases (1). According to the most commonly cited definition, an STF is defined as a fracture in femur occurring within the proximal 5 cm of the lesser trochanter (2), or more generally, within the proximal one-quarter of the femur (3). Despite variations in definition, the preferred treatment option in children and adolescents remains controversial (1).

Although open reduction and internal fixation (ORIF) is associated with lower complications (4), there is a broad spectrum of implant choices on the market. Despite its pre-contoured shape, proximal femur locking compression plate (PFLCP) is not the recommended choice (5); according to Shah et al., PFLCP does not provide a rigid fixation, which ultimately increases the chances of developing coxa vara and implant failure (5). Therefore, it is our impression that this implant is to be kept as adjuvant to other implants when fixation is not possible with other extramedullary implant and with the consideration that patient may not be able to walk without support before 4 months or before radiologic assessment.

However, adult proximal humerus internal locking system (PHILOS) plate has previously shown satisfactory results (6), but it is not the treatment choice mostly used in literature. In the current study, we aim to evaluate the clinical and radiographical results of PHILOS plate in STF among school-aged pediatric patients.

## Methods

**Procedure:** The patients underwent ORIF via a lateral approach. We used a PHILOS plate for internal fixation (Figure 1). After fluoroscopic control, the fascia and skin

were sutured in separate layers. Additionally, we used a drain and a long leg splint for all patients.



**Figure 1.** Anteroposterior (AP) radiograph of case 1 (A), case 2 (B), case 3 (C), and case 4 (D)

**Post-Operative Protocol:** All patients were instructed to be non-weight bearing using two crutches, starting the day after the surgery and continuing for the first six weeks. Active knee bending and hip range of motion (ROM) exercises were encouraged beginning on the second post-

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operative day, depending on pain tolerance. Stitches were removed on tenth to twelfth post-operative day. Patients were allowed to bear toe-touch weight once radiographic union occurred and were gradually permitted to bear more weight based on clinical and radiographical evidence of healing. Fracture union was defined as the absence of pain during weight bearing or palpation of the fracture line, as well as the presence of bridging callus (7). Full weight bearing was allowed after 12 weeks. All patients were followed after the surgery for at least one year and evaluated using the Flynn scoring system (8) and the Beatty radiologic criteria (Figure 2) (9).



**Figure 2.** Examination shows perfect rotation (A), extension and weight-bearing (B), hip flexion (C), and knee flexion (D)

## Results

**Patient Information:** Herein, we report four cases of STF in school-aged pediatric patients admitted to our center. The demographic data are summarized in table 1.

	Case 1	Case 2	Case 3	Case 4
Age (year)	10	10	15	7
Gender	Boy	Boy	Boy	Boy
BMI (kg/m <sup>2</sup> )	21.42	22.95	22.10	21.60
Trauma mechanism	RTA	RTA	RTA	RTA
Side of injury	Right	Right	Left	Right
Fracture pattern	Long oblique	Short oblique	Transverse	Short oblique
Hospitalization (day)	4	3	3	3
Hb decrease (g/dl)	1.2	1.4	1.2	3.0
Time to union (week)	9	7	8	7
Operation time (minute)	130	150	180	120
Flynn	Excellent	Excellent	Excellent	Excellent
Beatty	Satisfactory	Satisfactory	Satisfactory	Satisfactory

BMI: Body mass index; Hb: Hemoglobin; RTA: Road traffic accident

### Case 1

A 10-year-old boy sustained a long oblique STF following a fall from his bicycle. He had no significant medical history. His weight was 42 kg, with a body mass index (BMI) of 21.42 kg/m<sup>2</sup>. The pre-operative hemoglobin (Hb) was 10.2, that decreased to 9 after the surgery. The

operation duration was 130 minutes, and the hospitalization period was four days. In the routine follow-up visits, the fracture united at ninth week.

### Case 2

The patient, a 10-year-old boy, sustained a short oblique STF and an open wound of the knee joint on the contralateral side following a road traffic accident (RTA). He underwent irrigation and debridement (I&D) prior to STF fixation. His weight was 45 kg, with a BMI of 22.95. His pre-operative Hb level was 10.9, that dropped to 9.5 after the surgery. The operation duration and hospitalization period were 150 minutes and 5 days, respectively. The fracture united by the seventh week.

### Case 3

A 15-year-old boy sustained a transverse STF following RTA. He had a history of mental retardation and seizures. Concordant with neurology consult, sodium valproate (Depakine) was administered prior to surgery. His weight was 58 kg, with a BMI of 22.10. His pre-operative Hb level was 10.5, which decreased to 9.7 after the surgery. The operation duration was 180 minutes, and he was hospitalized for three days. The fracture united by the eighth week.

### Case 4

A 7-year-old boy with history of attention deficit hyperactivity disorder (ADHD) sustained a short oblique STF. He weighed 38 kg, with a BMI of 21.16. Pre-operatively, his Hb level was 13.2, which decreased to 10.2 after the surgery. The operation duration was 120 minutes, and he was discharged after 4 days of hospitalization. Fracture union occurred by the seventh week.

**Follow-up and Outcomes:** The mean hospital stay was 3.25 days. All patients showed union and were able to bear full weight after three months. Based on the Flynn scoring system at the last follow-up visit, all patients had excellent clinical outcomes. According to this classification, excellent results were characterized by a shortening of less than one cm, malalignment less than five degrees, and no pain. Based on the Beatty scoring system at the last follow-up visit, all patients demonstrated satisfactory radiological outcomes. According to this classification, satisfactory results were characterized by a shortening of less than one cm, no lengthening, coronal angulation less than five degrees, and sagittal angulation less than 10 degrees. We observed no complications, including infection, nonunion, implant failure, avascular necrosis of the femoral head, heterotopic bone formation, and limb length discrepancy (LLD).

## Discussion

A variety of options have been introduced for the management of pediatric STF, yet the best option remains controversial. At our center, the PHILOS plate was adopted for this fracture among school-aged children. We closely observed our cases through regular follow-up visits. Based on clinical and radiological criteria, we attained good outcomes without any complications. Specifically, there were no malunion, nonunion, loss of reduction, limping, LLD, or surgical site infection (SSI).

Previously, Baumgaertner et al. demonstrated that the ideal internal fixation device for fractures in subtrochanteric region should resist the deforming forces including flexion, external rotation, varus collapse of proximal segment, and medialization of distal segment (10). According to our results, this concept appears to be valid for PHILOS plates in STFs.

Table 2. Reviewed articles

Study	Year	Cases	Diagnosis	Age (year)	Gender	Outcome
Caglar et al. (11)	2022	18	STF	10-16	Girl/ Boy	HHS (mean $\pm$ SD) = 92.25 $\pm$ 5.61
Patrikov et al. (12)	2022	6	UBC	7-16	Boy	Time to union: 4.8 months
Tsutsumi and Mammoto (13)	2022	1	Pathologic fracture	10	Boy	Complete union in 12 months, no obvious growth failure
Danisman et al. (14)	2022	9	STF	10-12		
Chetia et al. (15)	2020	13		5-12.5		
Newbury et al. (16)	2020	1	ABC	14	Boy	Asymptomatic
Chew et al. (17)	2018	1	STF	13	Girl	Union in 5 months and performing routine activities without any difficulty
Kumar et al. (18)	2017	1	Proximal femur fracture	10	Girl	HHS = 95
Jusoh (19)	2017	1	Intertrochanteric fracture	14	Boy	
Shaw et al. (20)	2014	1	Periprosthetic fracture	18	Girl	Union after 11 months
Gogna et al. (6)	2014	8	STF	10-16		All united
Cortes et al. (21)	2011	1	Nonunion after proximal femur plating	11	Boy	Uneventful healing

STF: Subtrochanteric fracture; HHS: Harris hip score; ABC: Aneurysmal bone cyst; UBC: Unicameral bone cyst; SD: Standard deviation

Pediatric patients treated with titanium elastic nails (TENs) recover faster than those treated with traction and a spica cast, with fewer complications (8).

As opposed to locking plates (LPs), a shorter operation time, less intraoperative hemorrhage, and a more quickly fracture healing occurs after surgery using TENs, enabling earlier full weight-bearing. LPs can lower the incidence rate of postoperative angulation, rotation, and inversion deformity as well as the operator's exposure to X-rays. Therefore, TENs and LPs appear as the best internal fixation procedures for managing STF in children (22).

Plate fixation of pediatric subtrochanteric femur fractures is associated with better outcome scores and a lower overall rate of complications compared to TENs (22). Triple TENs, compared with LPs, have demonstrated significantly shorter operative times, reduced estimated blood loss, and shorter hospital stays. Both TENs and LPs groups have yielded satisfactory outcomes in school-aged children with STFs. Thus, TENs and LPs remain feasible choices for STFs in school-aged children (23).

Gogna et al. reported eight 10-16-year-old cases of STF treated surgically with PHILOS plates, all of which united (6). Shaw et al. managed a periprosthetic fracture in an 18-year-old girl that united in 11 months (20). Numerous studies confirm the benefits of PHILOS plates in managing pediatric STF (11, 15, 17, 19). Notably, PHILOS plates have been successfully employed in managing pathologic fractures, including those associated with unicameral bone cyst (UBC), with excellent outcomes and no major complications (23).

Caglar et al. fixed 30 cases of subtrochanteric femoral shortening osteotomy during total hip arthroplasty (THA) for Crowe type IV developmental dysplasia of the hip (DDH) (24). They reported one case of nonunion and no implant failure. Reviewed studies recruiting PHILOS plates are summarized in table 2.

**Limitations:** Firstly, the four cases for this study could be a bit low, and more studies are needed to introduce PHILOS plate as treatment of choice. Secondly, we just used traumatic patients and did not use pathologic fractures. However, in these cases, the outcome was satisfactory.

### Conclusion

Internal fixation of schooled-aged pediatric STF with PHILOS plates proves to be a good treatment choice with satisfactory clinical outcomes. The advantage of this plate is that it can accommodate many screws at appropriate positions and angles without damaging the physis, making it a useful approach for managing pediatric STFs.

### Conflict of Interest

The authors declare no conflict of interest in this study.

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