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PEDIATRIC SUBTROCHANTERIC FEMUR FRACTURES: AN INNOVATIVE TECHNIQUE OF FIXATION USING 1/3RD SEMITUBULAR PLATE

Orthopaedics

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ABSTRACT

Introduction: Proximal subtrochanteric femur fractures are challenging in terms of management due to anatomic constraints, inherent fracture instability, no direct control of the short proximal fragment, and the close proximity of fracture to the physeal plate. Surgical intervention results in better outcome with faster healing and less eventual complications. We describe and analyse an innovative method of fixation using custom bend 1/3rd tubular plate, which we found to be simple and cost effective to use, for treatment of subtrochanteric proximal femur fracture in pediatric age group patients.

Material and Methods: Nine children were included in the study within the age group of 3-6 years, who sustained subtrochanteric fracture according to our criteria. Fixation was done with innovative technique of custom bend 1/3rd semitubular plate. Clinical and radiological assessment includes duration of bone healing, hip and knee range of motion and functional activities.

Results: All fractures healed with good anatomical alignment within an average of 9.2 weeks. The most common fracture pattern seen in children was a transverse pattern. Clinically all patients had good range of motion in hip and knee joints at the last follow up. Patients had been actively involved in sport activities with no restriction. The average follow up was 17.8 months (range 12-24 months).

Conclusion: Semitubular plate expands the option available for challenging fixation in paediatric subtrochanteric fractures. It is safe, cheap and easily reproducible technique in treating subtrochanteric femoral fractures in children within age group of 3-6 years.

KEYWORDS

Introduction

Pediatric subtrochanteric hip fractures receives special attention not because of the frequency of occurrence of these injury patterns but due to high rate of complications associated with these injuries. Although they represent 5% to 10% of the pediatric femur fractures, but there actual incidence is still questionable, as there are no clear consensus in literature on the universally acceptable definition of a subtrochanteric area. Studies tends to include proximal femoral fractures in subtrochanteric area, reporting higher incidence rates [1]. These fractures typically extends upto 1-2 cms below the lesser trochanter. They remain a challenging subset of fractures to deal, with loss of reductions and nonunions being the commonest complications. However, not enough literature is available to support a standard algorithmic approach for treatment of these fractures, minimally displaced fractures in younger children (less than 4 years) are treated non-operatively with hip spica, while surgical interventions are reserved for older group of children.

Subtrochanteric fractures behave differently from other pediatric femoral fractures in terms of high rates of communition, shortening and coronal plane angulation [2]. They are more prone to post reduction displacement due to strong divergent pull of muscles in the trochanteric area. Additionally, the common fracture patterns in subtrochanteric are length unstable fractures and they have limited remodelling potential. Proximal meta-diaphyseal femur fractures are challenging in terms of management due to anatomic constraints, inherent fracture instability, no direct control of the short proximal fragment, and the close proximity of fracture to the physeal plate. These unique features makes conservative treatment measures less amenable in children older than 4 years of age. There are supportive evidences available in literature, suggesting operative treatment over conventional conservative methods for treatment of adolescent subtrochanteric fractures, however the ideal method of fixation requires further research [3,4]. Surgical intervention results in better outcome with faster healing and less eventual complications of avascular necrosis of femoral head and subsequent limb length discrepancy, earlier ambulation and better psychosocial outcome.

Patient's age, Body Mass Index (BMI), fracture pattern, associated injuries and surgeon's preference should be taken into consideration while deciding upon the appropriate treatment and hardware selection for these fractures. Various different modalities of implant constructs have been used ranging from historically used smooth pins to recently available variable angle proximal femur locking paediatric hip plates. However, each has its own set of pros and cons, with no clear guidelines for the implant selection. Aim of our study is to describe and analyse an innovative method of fixation using custom bend 1/3rd tubular plate, that the senior author (SAP) found to be simple and cost effective to use, for treatment of subtrochanteric proximal femur fracture in pediatric age group patients. Furthermore, it is our goal to review the literature on varied treatment modalities for skeletally immature children with subtrochanteric femur fractures.

Material and Methods

After approval from institutional review board of our hospital, in accordance with the inclusion and exclusion criteria, nine children with proximal femur subtrochanteric fractures were treated with custom bend 1/3rd semitubular plate between January 2013 to December 2015. There were 5 girls and 4 boys with an average age of 4.5 years. Injury was caused by motor vehicle accident in 6 patients, while remaining three had sustained it following fall from height. Two patients had associated head injuries, one patient had fractured forearm and six patients had isolated subtrochanteric femur fractures (Table 1). The inclusion criteria were: (1) age between 3 to 6 years, (2) fracture within 10% of the proximal femoral shaft, (3) closed injuries. Pathological fractures, association with ipsilateral or contralateral lower limb fractures, fractures associated with neuro-vascular injury were excluded from the study. The guardians of the children were informed of the study, and an informed consent was obtained before the surgery.

We labeled a fracture as "subtrochanteric" that is located within 10% of the total femur length below the lesser trochanter. Full length anteroposterior X-ray of the opposite uninjured limb was taken, when the fracture was located in the proximal femur area and is clearly not defined as neck or intertrochanteric fracture. The total length of femur is calculated as distance between the top of femoral head and the medial femoral condyle. The distance between the inferior aspect of lesser trochanter and the fracture site was measured. If the distance is <10% of the total femoral length, the fracture is defined as "subtrochanteric". There is no classification described for paediatric subtrochanteric femoral fractures. Although, author's have discussed about using Seinsheimer classification, but it is more appropriate to use it in adolescent children where fracture configuration is more clear. The fracture types were classified according to fracture geometry. Radiograph revealed that there were 5 patients with transverse type fracture, 2 patients had short oblique and 2 patients had subtrochanteric fracture extending into the intertrochanteric area. All the patients were initially haemodynamically stabilized upon arrival in emergency department and posted for surgery on the next working day except the two patients with head injury, who were operated after 3 days. The surgeries were executed by senior author (SAP) on planned basis.

Surgery was done in supine position with a rolled towel placed under the operated hip. Manual reduction and distraction was attempted for correction of angulation and length. Standard lateral vastus medialis splitting approach was used for exposure. Most of the time, the proximal fragment was found abducted and flexed, making reduction a tedious task. Direct open reduction of fracture fragments was performed. Sometimes fracture was stabilised temporarily using k-wires. K-wires should be inserted such that they should not interfere with placement of final implant. Site is chosen on the lateral cortex 2 cm below the greater trochanteric physis, for placement for guide wire directed towards the head, respecting the physis. The first wire was inserted using jig which has three holes, so that the additional two wires can be inserted. After placement of wires, position was checked under image intensifier, they should lie in the centre in both anteroposterior and frog lateral view. The remaining lateral cortex between the holes is broken with the help of a small osteotome. Appropriately sized 3.5mm 1/3rd semitubular plate was punched into the slot. Preferably 2 or 3 screw holes should cross the lateral cortex to achieve a good hold. Remaining plate is bend at the edge and fixed provisionally with the shaft. Final reduction is checked under image intensifier, if found satisfactory, fixation was completed by adding screws in the distal holes. Additional screw can be placed in the neck region if the fracture extends into the inter-trochanteric area. Wound was closed in layers over suction drain.
Post operatively patients were immobilised in a cylindrical cast or a long knee brace for 3 weeks.This prevents the knee mobilisation, which ultimately secures the fixation around the hip. Following which patients were given knee mobilisation exercises. Ambulation was kept partial weight bearing using walker until radiological union was evident, gradually progressing to full weight bearing as tolerated. Clinical and radiological assessment includes duration of bone healing, hip and knee range of motion and functional activities.

Results

Radiographic evaluation revealed that all fractures healed with good anatomical alignment within an average of 9.2 weeks (range 6 to 12 weeks) (Fig. 1). The most common fracture pattern seen in children was a transverse fracture. All patients had grade 0 or 1, using the Winquist and Hausen classification [5]. 3.5mm 1/3rd semitubular plate was used in all patients. One patient requires additional screw placement in the neck region outside the plate, to secure the intertrochanteric extension of the fracture (Fig. 2). There were no obvious complications except superficial wound break down in one patient which responded to oral antibiotics and regular dressing. Another patient had constant irritation at the lateral aspect of thigh, after fracture union which was treated with local massage and physiotherapy. One patient had leg length overgrowth of 0.8 cms on clinical examination at last follow up of 20 months. Clinically all patients had good range of motion in hip and knee joints at the last follow up. Patients had been actively involved in sport activities with no restriction. There were no incidences of implant failure, re-fracture or avascular necrosis of femoral head. All patients were discharged on 2nd day post-operatively except the two patients with head injury who had a longer stay. The average follow up was 17.8 months (range 12-24 months).

Discusion

Pediatric subtrochanteric femoral fractures are relatively rare group of injuries and cannot be treated on the principles of fracture in “small” adults. The anatomical constraints in children with proximity of fracture line to the trochanteric physis and the capital femoral epiphysis, adds to challenges in treating theses fractures avoiding subsequent late complications. Reported incidence ranges from 4% to 17%, but the authors believe that actual incidence is much less, as there is no universally accepted criteria to define subtrochanteric area in children [6]. In children the fracture is labeled as “subtrochanteric” that extend from intertrochanteric line to adductor tubercle or the extension is upto 3 cms below the lesser trochanter [7]. In our series the definition employed was that of Mathew and Jeffery, where the fracture was considered as subtrochanteric when the fracture distance is less than 10% from lesser trochanter compared to total shaft length, an area in which the muscle deforming force results in difficulty to control and maintain reduction [8]. It has been observed that these injuries are less likely to occur in older children and adolescent due to good cortical bone maturation in metaphyseal area. Majority of this fracture configuration is seen in first decade of life with mean age of around 6 years [9].

There is no pediatric specific classification to account for physeal involvement, which is an important associate with this injury, even using Seinsheimer classification is not appropriate for children <8 years [10]. We have described the fracture according to geometry of fracture configuration, which we feel is more valid approach to assess subtrochanteric fractures in children. Conventionally the proximal femoral fractures have an excellent prognosis with non-operative therapy, however, close treatment is fought with his own complications of fracture displacement, frequent radiographs, malunion and growth arrest in later life. Due to the tri-planer pull of muscle proximally it is difficult to control the proximal fragment with traction or in hip spica. For this reason, trend has now shifted towards early surgical intervention. Surgical stabilisation of the fracture offers the advantage of good nursing care and early mobilisation, reducing the morbidity significantly.

Enough evidence is available in literature to prove superior results with internal fixation compared to non-operative approach [4,11]. Various fixation modalities has been described for paediatric subtrochanteric fractures with mixed results. Parikh SN et al, documented 36 subtrochanteric fractures in children with age group of 5-12 years, treated with elastic stable intramedullary nails. They concluded that, although complications rates are high unto 22%, but still elastic nailing is a reasonable option for these injuries [12]. Flexible intramedullary nailing has been considered as treatment of choice in paediatric femoral fractures but lack of rotational control and inadequate fixation are some of the problems associated with it. It is technically demanding to achieve and maintain reduction in proximal fragment using flexible nails. Also, these elastic nails work on the principles of 3-point fixation and more suited for diaphyseal fractures. External fixators alone or an add on adjuvant to intramedullary nailing has been used, but the rates of pin tract infection, refracture and loss of reduction are high [13]. A recent study on external fixation with low profile Ilizarov frame for paediatric subtrochanteric fractures using calcar pins reported good results as it controls the rotation and proximal fragment various better [14]. Authors unanimously do not agree upon the use of external fixators for proximal femoral fractures as the proximal fragment is too small and difficult to control with pins and chances of post-reduction displacement or displacement on first follow up is very high. Intramedullary nails or external fixators have not sufficiently addressed the challenges of fracture type with respect to maintenance of reduction, post operative ambulation and weight bearing.

The most important confounding factor for fracture in subtrochanteric region is the proximity of fracture to physis and the varied fracture patterns, that makes careful selection of implant hardware important in obtaining a successful outcome. The advantages of plate fixation include anatomical reduction, less interference to hip function and early return to pre-operative activities. A variety of fixation plates has been described for paediatric subtrochanteric fractures with mixed results. Ward et al. used 4.5mm dynamic compression plate for treatment of femoral fractures in 25 children with age group of 6-16 years. They reported good results with average time to fracture union was 11 weeks [15]. Periarticular locking plates, made specifically for opposite distal femur, has produced encouraging results in adults [16]. Subsequently, proximal and distal tibia locking plates, PHILOS plate has been tried in paediatric proximal femoral fractures with amenable outcome. Although, these plates has been designed for specific anatomic sites, but this does not preclude their use at other sites. Sanders S et al. used lateral proximal tibia locking plate for adolescent subtrochanteric hip fracture and medial distal tibial locking plate for paediatric subtrochanteric hip fracture, and found that these plates provided adequate precontoured plate-bone interface for a stable construct [17]. Recent introduction of variable angle LCP Paediatric Hip Plate, has shown excellent results with low complication rates for correction of pathological conditions of proximal femur and for fixation of peritrochanteric fractures [18]. But, these are expensive and more suitable for older children.

The 1/3rd tubular plate is an attractive and innovative alternative for rigid fixation in paediatric subtrochanteric femur fractures. These plates are thin and malleable, easy to contour, provides sufficient stability, cheap and easily available. The proximal part of the plate is inserted in femoral neck similar to blade plate, following which the distal part of the plate is moulded and fixed to the shaft. This provides rigid fixation with good rotational control, and

allows good compression at the osteosynthesis site (Fig. 3). Additional screw may be inserted along side the proximal part of plate for compression in fractures extending unto the neck or intertrochanteric region. We report good radiological and functional results with this fixation. Patients rapidly recovered back to pre-injury status, and there were no complications of nonunions or implant failure. Sehr JR et al. used semitubular plate, fashioned into a blade plate device, for fixation of fractures and osteotomies around the proximal humerus [19]. They reported fracture union by 4 months with good functional recovery. They even analysed the strength of fixation compared to AO 'T' plate, and found no statistical difference with regard to load to failure, yield load, energy absorbed to failure, and stiffness.

Proximal femoral epiphysis should not be perforated while drilling with blade plate reamer, to make space for moulded proximal part of plate to fit in. Additional screws placed for compression should respect the epiphysis. However, in special situations like extension of subtrochanteric fracture in the neck region, requires placement of the screws through the epiphysis to achieve adequate fixation. Although, the risk of growth arrest increases but it much less than the risk of instability or nonunion [20]. In none of the cases presented in our study, we have violated the proximal femoral epiphysis. The size of the plate is dependent on patient's age and weight. We have used 3.5 mm 1/3rd semitubular plate in all our cases. Author's believe that this technique of fixation is not good for older children >6 years, as fixation stability remains the primary concern in older children, which cannot be adequately achieved with it. Early implant removal in not a priority as growth plate is left untouched. Surgery was performed in supine position with a folded sheet placed under the operated hip. Lateral approach was used which provides direct access and easy manipulation of the fracture. Antero-posterior and lateral images of the hip can be easily taken by moving the hip in frog lateral position. None of the patients has been given hip spica post-operatively, but 3 weeks of immobilisation in a cylindrical cast or long knee brace is needed for securing fixation.

Loss of correction or plate breakage was not observed in our series of patients. Plate related complications has been observed in few studies, with the added disadvantages of re-surgery for implant removal, poor cosmetic scar, blood loss and bone over growth [21]. However, patients treated with plate reported earlier return to school compared to those treated conservatively [4]. Excessive periosteal stripping done during plate application may lead to overgrowth later. Studies have reported considerable overgrowth following plate fixation, but it is more significant in children over 10 years of age [15, 22]. In our study we cannot comment on overgrowth as it requires longer follow up till adulthood. Implant failure is an undesired complication for any surgeon. Ward et al. reported plate breakage in a patient who begun early weight bearing [15]. Similarly, Fyodorov et al. documented implant failure in 2 of 23 patients treated with dynamic compression plate [23]. In our study, hardware failure did not occur in any patient till last follow up. Reports are controversial in relation to the need for implant removal. Ward et al. had a refracture through the screw tract in one out of 15 patients who underwent plate removal [15]. Eren et al. also reported a refracture 9 years following plate removal [24]. Author's believe that plate removal should not be advised in asymptomatic patients. Since, none of our patients report any implant related complications, which lead us to leave implants in place during the last follow up. In general, the applicability and handling of this 1/3rd semitubular plate was simple and excellent.

Our study has few limitations. It is a single centre study with small number of patients enrolled. To have a firm conclusion, randomised controlled trials with larger sample size is needed. It has been proven, that excessive dissection and periosteal stripping during plate application may lead to overgrowth in children. Although, it is not a significant problem, but we should have taken it in consideration by doing a scannogram at the last follow to document for leg length discrepancy.

Conclusion

As a conclusion of our study, we believe that 1/3rd semitubular plate expands the option available for challenging fixation in paediatric subtrochanteric fractures. It is safe, cheap and easily reproducible technique in treating subtrochanteric femoral fractures in children within age group of 3-6 years. This new innovative configuration of custom bend plate is a reasonable option and is not a very technically demanding surgery.

Caption and Legends

Table 1: Patient demographics

Case No.	Age (yrs.)	Sex	Mechanism of injury	Associatd injuries	Fracture pattern	Time to union (Weeks)	Complications	F/u period (months)
1	3.8	M	Accident		Transverse	6	0.8 cms overgrowth	20
2	5	F	Fall from height		Transverse	12		13
3	6	M	Accident		S/T with I/T extension	10		12
4	4.2	F	Accident		Short oblique	7		15
5	3.5	F	Accident		Transverse	11	Superficial wound breakdown	18
6	3	M	Accident	Head injury	S/T with I/T extension	9		20
7	5.5	F	Fall from height	Head injury	Short oblique	6		24
8	4.8	F	Fall from height		Transverse	12	Irritation at lateral aspect of thigh	20
9	5.2	M	Accident	Forearm fracture	Transverse	10		18

Figure 1: Pre-operative radiograph of 5years old girl (Case No.2) who sustained transverse type of subtrochanteric fracture, immediate post-operative imaging and showing complete union at 13 months follow up.

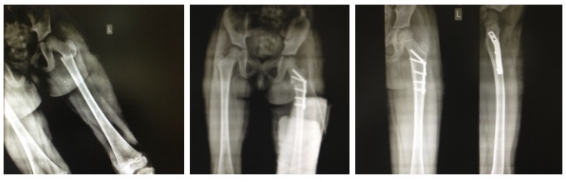
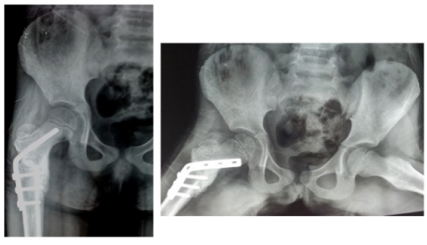


Figure 2: Radiograph of 6 years old male showing subtrochanteric fracture with inter-trochanteric extension. Follow up radiograph shows custom bend 1/3rd semitubular plate insitu with additional screw placed across the neck for better stability.

Figure 3: Radiograph showing good osteosynthesis in a short oblique subtrochanteric area, using custom bend 1/3 semitubular plate.



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