

Functional Outcome of Dynamic Hip Screw in Pediatric Femoral Neck Fractures : An Institutional Five-Year Study

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ABSTRACT

Introduction: Pediatric femoral neck fractures are rare fractures constituting less than 1% of all fractures in the pediatric population. This study evaluated the functional outcome of pediatric DHS as an internal fixation device in such fractures.

Methodology: Retrospective review and analysis of 10 patients aged 15 years or less who had sustained neck of femur fracture and were treated with Internal fixation, either open or closed reduction techniques with Pediatric Dynamic Hip Screw in our institution over a period of five years from February 2018 to January 2023. Patients were classified based on demographic features. The Delbet system of classification was used. The final outcomes of patients were recorded based on the Ratliff system of clinical and radiological assessment.

Results and Observations: Mean age was 11.4 years. 7 were males and 3 females. Patients were followed up for an average period of 22.6 months. RTA was the commonest mode of injury. Delbet type II was the commonest pattern seen in 50% of cases. 8 out of 10 patients (80%) had 'satisfactory' outcomes. Complications noted were Limb-length discrepancy, Avascular necrosis, Coxa vera, Non-union, Implant loosening, Hypertrophic scar at surgical site.

Conclusion: Pediatric femoral neck fractures are rare fractures and associated with many complications, AVN being the most dreadful. Early active intervention with anatomical reduction and stable fixation helps in minimizing these complications. Pediatric dynamic hip screw can be used as a preferred implant of choice with or without fibular strut graft.

Keywords: Pediatric femoral neck fractures, DHS, AVN, Delbet, Ratliff.

Date of Submission: 14-04-2023

Date of Acceptance: 27-04-2023

I. INTRODUCTION

Pediatric femoral neck fractures are rare fractures constituting less than 1% of all fractures in the pediatric population.^[1] These occur most commonly following severe violence or high energy trauma,^[1] unlike in the elderly population with osteoporosis where a minor fall can also cause a fracture. This is attributable to the thick and strong periosteum cover and a high bone mineral density in the pediatric age group.^[2]

Historically these fractures were poorly understood due to their rarity and it was said that a surgeon might not find a single such case in his entire lifetime. In 1960s, Ratliff was the first in history to study in detail the natural history of such fractures and the value of different methods of treatment and the associated complications. These fractures were so rare that Ratliff recorded only 1 such case of pediatric neck of femur fracture against 130 adult cases.

The treatment modalities were not standardized and outcomes were poor with high complication rates. These complications included most commonly the avascular necrosis (AVN) of the femoral head, delayed union or non-union, coxa vera, premature physeal closure, limb length discrepancies.^[3] In the following years, more studies on the subject lead to better understanding of the fractures, treatment options got more standardized with improved outcomes.

This paper is based on the study of 10 such cases which underwent internal fixation (Open or Closed reduction) by use of pediatric Dynamic Hip Screw over the course of five years. Outcomes were recorded based on the clinical and radiological findings by retrospective review and analysis and the complications associated were studied.

II. MATERIALS AND METHODS

We performed a retrospective review and analysis of 11 patients aged 15 years or less who had sustained neck of femur fracture and were treated with Internal fixation, either open or closed reduction techniques with Pediatric Dynamic Hip Screw in our institution over a period of five years from February 2018 to January 2023.

One patient with less than one year of follow-up was excluded from the study. So, a total of 10 patients who had completed a minimum follow-up period of at least one year qualified for our study. An informed and written consent was taken from parents of all the patients before conducting the study.

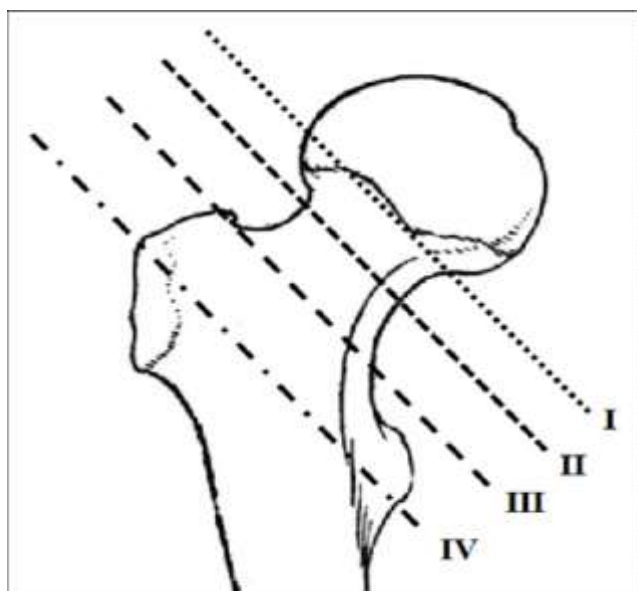
The patients were classified based on the demographic features i.e. age and gender, mode of injury, type of fracture, displaced or undisplaced, whether closed or open reduction techniques.

The Delbet system of classification [Fig.1] adopted by Colonna^[4] was used for classifying the pediatric femoral neck fractures in our study. These were further sub-categorized based on whether the fracture was displaced or undisplaced. The treatment modality applied was closed or open reduction and internal fixation with pediatric dynamic hip screw, with or without fibular strut graft. The final outcomes of patients were recorded based on the Ratliff system of clinical and radiological assessment^[1] [Table.1] at the end of the last follow-up visit, minimum one year post surgery and maximum till five years. A good outcome was recorded as a 'satisfactory outcome' whereas fair and poor outcomes or the presence of complications were recorded as 'unsatisfactory outcome'.^[5]

We evaluated pre-operative, post-operative and the final antero-posterior (AP) and lateral views pelvic radiographs of all patients. These were evaluated for presence of any deformity, delayed union or non-union, joint congruency, arthritic changes, neck-shaft angle, premature physeal closure, hardware integrity and avascular necrosis (AVN). AVN was further classified according to the Ratliff classification system.^[1] Limb length discrepancy was measured clinically.

Table.1:Ratliffsystem ofclinicalandradiologicalassessment

Parameters	Good	Fair	Poor
Pain	None or 'ignores'	Occasional	'Disabling'
Movement	Full or terminal restriction	Greater than 50%	Less than 50%
Activity		Normal or avoids games	Restricted
Radiographic features	Normal or some deformity of the femoral neck	Severe deformity of the femoral neck. 'Mild' AVN	Severe AVN. Degenerative arthritis. Arthrodesis



Type I: Trans-epiphyseal
 Type II: Trans-cervical
 Type III : Cervico-trochanteric
 Type IV: Intertrochanteric

Fig.1:Delbetclassificationofpediatricneckoffemurfractures

III. RESULTS

The mean age of patients included in our study was 11.4 years (Range 7 to 15 years). Amongst the total 10, 7 (70%) were males and 3 (30%) were females. Patients were followed up for an average period of 22.6 months (Range 14 to 45 months). A variety of mode of injuries were noted, commonest being fall from height, followed by road-traffic accident, fall of heavy object and fall during playing. Out of total 10 patients, 5 (50%) sustained injuries following fall from height, 3 (30%) following road-traffic accidents and one (10%) each following fall of heavy object and fall during playing. [Table.2] Amongst the three who suffered RTA, 2 sustained injuries following fall from a motor cycle and the other one who was a pedestrian going by a vehicle. We found 7 (70%) patients with isolated femoral neck fractures. Amongst the remaining three, one sustained head injury with scalp and facio-maxillary lacerations but with no brain parenchymal injury. One sustained blunt trauma abdomen which was managed conservatively by the Dept. of General Surgery. The other one had associated calcaneal fracture. [Table.3]

Table.2:Distribution of cases based on the mode of injury

Mode of injury	No. of cases
Fall from height	5
Road traffic accident	3
Fall of heavy object	1
Fall during play	1

Table.3:Associated injuries in 30% of cases

Associated injury	No. of cases
Head injury without brain parenchymal injury	1
Blunt trauma abdomen	1
Calcaneal fracture	1

Patients were classified according to the Delbet system of classification^[4] for pediatric femoral neck fractures. In our study, we found 5 patients (50%) of Delbet type II (Trans-cervical), 4 patients (40%) of Delbet type III (Cervico-trochanteric) and the remaining one case of Delbet type IV (Intertrochanteric). Not a single case of Delbet type I (Trans-epiphyseal) was found in our study. These fractures were further divided into displaced and undisplaced. 6 out of 10 cases (60%) were displaced fractures and the remaining 40% were undisplaced. Patients were put on traction table and closed reduction was tried initially for all the patients under fluoroscopy guidance, irrespective of whether the fracture was displaced or undisplaced. In case closed reduction had failed, open reduction was done and internal fixation done with pediatric dynamic hip screw, with or without fibular strut graft. 6 out of 10 patients (60%) underwent closed reduction and the remaining 4 (40%) underwent open reduction. 5 out of 10 patients (50%) were given fibular strut graft.

The final outcomes of the patients were assessed based on the Ratliff system of clinical and radiological assessment at the end of the last follow-up visit of each patient. 8 out of 10 patients (80%) had 'satisfactory' outcomes. The remaining two showed 'unsatisfactory' outcomes, one each with 'fair' and 'poor' outcome. The patient with 'fair' outcome presented with mild AVN changes and coxa vera deformity at the end of 45 months of follow-up. One with the 'poor' outcome showed no signs of radiological union and presented with pain, decreased range of movement and restricted activity. The complications are summarized in Table.4.

Table.4: Summary of complications

Complications	No. of cases
Limb-length discrepancy	2
Avascular necrosis	1
Coxa vera	1
Non-union	1
Implant loosening	1
Hypertrophic scar at surgical site	1

Although these fractures are required to be anatomically reduced and fixed on an emergency basis, however due to lack of resources these were conducted as routine elective procedures. Besides, initial management by quacks, delay in referrals from the peripheral hospitals and non-clearance from anaesthesia department also added to the delay in surgical intervention. The average surgical delay in our cases from the day of presentation was 4.5 days (Range 2 to 7 days).

Table.5: Summary of demographics, management, outcomes & complications of all cases

Sl.No.	Age/Sex	MoI	Delbet Type	Displaced/Undisplaced	Open/Closed Reduction	Fibular Strut Graft	Ratliff assessment	Follow-up (months)	Complications
1	12/M	Fall of heavy object	III	Displaced	Closed	Yes	Good	19	Shortening 1.5cm
2	7/F	FFH	III	Undisplaced	Closed	No	Good	16	-
3	10/M	FFH	II	Displaced	Open	Yes	Fair	45	AVN, Coxa vera, Shortening 2cm
4	11/M	RTA	II	Undisplaced	Closed	No	Good	33	-
5	15/M	RTA	III	Displaced	Open	Yes	Good	22	-
6	13/F	FFH	II	Undisplaced	Open	Yes	Good	28	Hypertrophic scar
7	8/F	Fall during play	IV	Displaced	Closed	No	Good	21	-
8	12/M	FFH	II	Displaced	Open	Yes	Good	32	Implant loosening
9	12/M	RTA	II	Undisplaced	Closed	No	Good	36	-
10	14/M	FFH	III	Displaced	Closed	No	Poor	14	Non-union

Note: MoI- Mode of injury, FFH- Fall from height, RTA- Road-traffic accident

IV. DISCUSSION

Pediatric femoral neck fractures are fractures of rarity and complications. Though these fractures are rare in children, the assumption of Hamilton^[19] that a surgeon might not encounter a single such case in his entire lifetime may not hold true because of the high incidence of road traffic accidents in this era. The most dreaded complication is avascular necrosis of the femoral head. Therefore an understanding of the anatomy of pediatric hip is important as it varies from an adult hip significantly in terms of its blood supply. Trueta in the 1950s pioneered the idea of dynamic nature of the vasculature of growing femoral head.^[6] The higher incidence of AVN in pediatric patients as compared to adult population was attributed to two main causes: (1) MFCA being the only source of blood supply to the femoral head during majority of childhood, whereas in adults collateral flow from the LFCA and ALT is present. (2) High-energy mechanism of injury required to cause a femoral neck fracture in children resulting in a higher rate of Superior Retinacular artery injury.^[7]

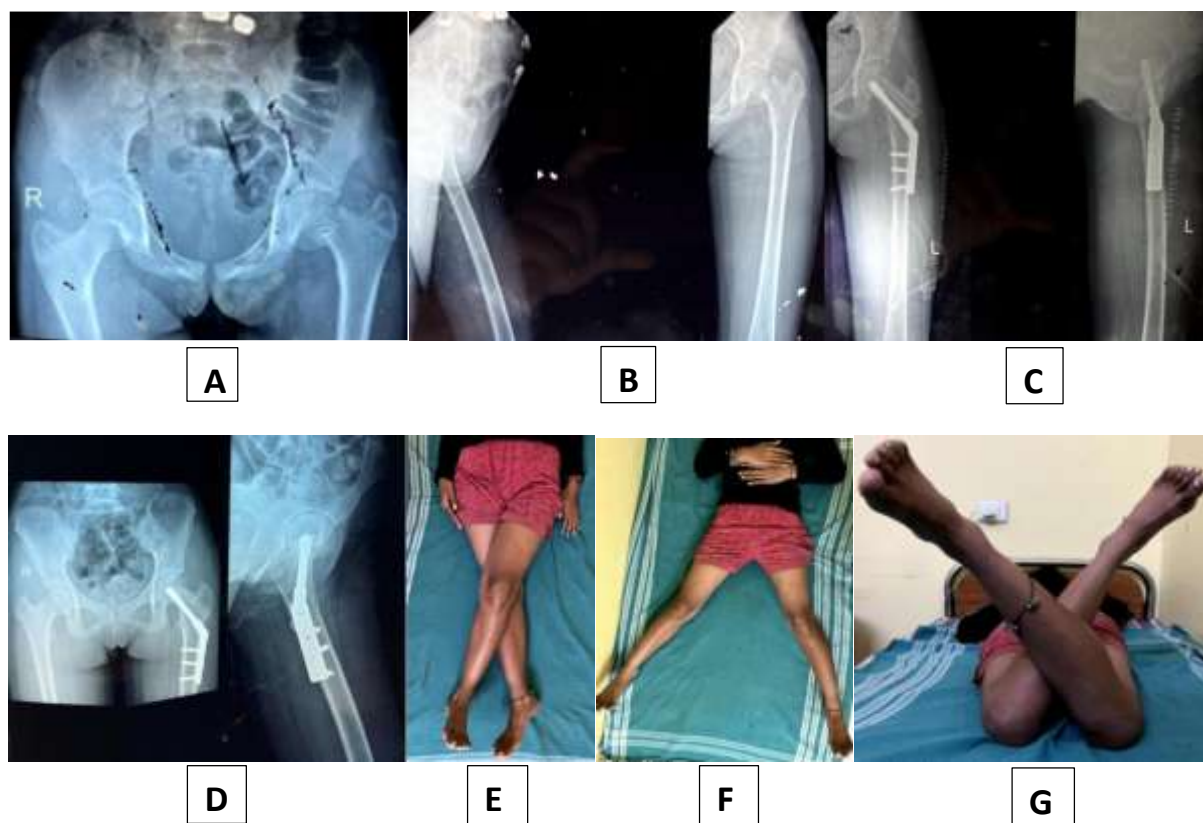
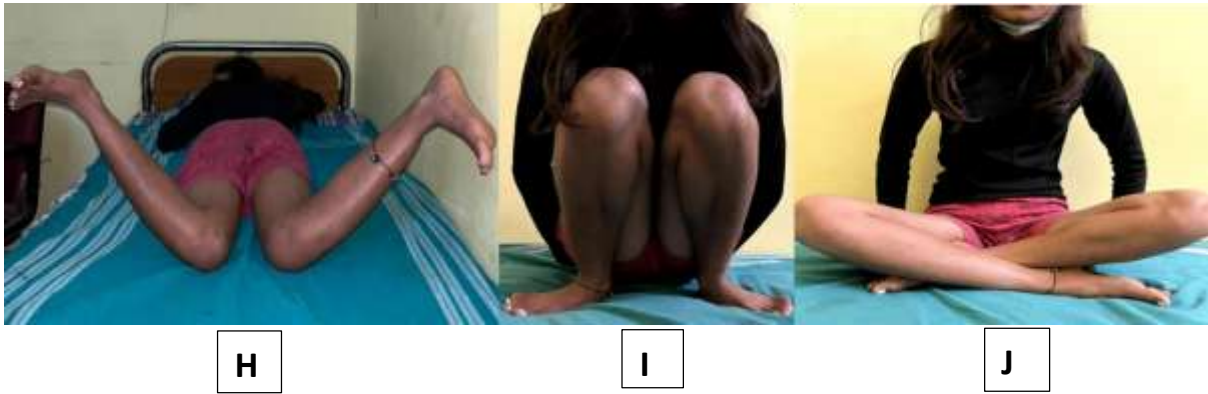


Fig.2: Radiological and clinical images of a girl aged 13 years with a fracture neck of femur, operated in our institution by open reduction and internal fixation with pediatric DHS and Fibular strut graft. Images A and B show Delbet type II femoral neck fracture. C shows immediate post-op. D shows signs of union. E-F show various ranges of motion at the final visit showing 'satisfactory' outcome.



Almost all the patients in our study sustained high-energy trauma like fall from height and road-traffic accidents which supports the fact that a high-energy force is required to fracture the femoral neck in children.^[8] This is attributable to the thick and strong periosteum cover and a high bone mineral density in pediatric population compared with the adult counterpart.^[5,9] Due to the same reason, associated injuries are found to be frequently present with pediatric femoral neck fractures. In our study, three patients had various associated injuries (30%). Therefore a detailed examination of all such patients is mandatory in the emergency room so that these associated injuries do not go unattended.

In our study, 50% of our patients presented with Delbet type II fractures followed by type III (40%) and type IV (10%). We did not find any patient with a type I fracture. So we came to the conclusion that Delbet type II fractures are the most common pattern whereas Type I fractures are very rare. Most of the available literature support similar findings.^[10,11]

Presence of growth plate adjacent to the fracture site makes the physes vulnerable to growth arrest secondary to compromised vascularity and direct trauma especially in Delbet type I fractures. Introduction of implant used for internal fixation through the physis can also lead to growth arrest. Such physal arrests can lead to deformity in the form of coxa vara and/or a limb length discrepancy (LLD).^[12-14] In our study, one case of coxa vera and two cases of shortening of the affected limb, one by 1.5cm and another by 2cm, compared to the normal side were found. In the former, neither the implant disturbed the physis nor there was a neck deformity. So it was assumed that the shortening might have occurred due to physal growth arrest by direct trauma and vascular compromise during the time of injury. In the latter, coxa vera deformity was associated with shortening.



Fig.3 : Radiographs of a 10 year old boy with fracture neck of femur,operated by ORIF with pediatricDHS and Fibular strut graft. ImageA shows Delbet type II fracture. Bshows intra-operative IITV image. Cshows immediate post-op. D showsfinal radiological status at 45 months of follow-up. There is coxa vera and mildAVNchanges.

The risk of AVN depends on a variety of factors such as age, degree of initial displacement of the fracture, delay in surgery, and the method of fixation.^[15] The most important factor for the development of AVN is the severity of vascular compromise sustained at the time of injury. AVN was reported in 10% of our patients. Based on the available literature, AVN is said to range from 6 to 70%, high in Delbet type I fractures, ranging from 70 to 100%.^[16-18] However, no patient in our study presented with a type I fracture. According to Moon et al.^[15] the rate of AVN in types II, III, and IV fractures were found to be 28, 18, and 5% respectively. In our study, only one patient with a type II fracture developed AVN and had an unsatisfactory outcome. However, his clinical outcome was considered fair with occasional pain and normal activities of daily living. Coxa vara is the second most common complication related to pediatric femoral neck fractures.^[20] We had one patient with coxa vara deformity with a neck-shaft angle of 120° which was associated with limb shortening of 2cm. The reported rate of infection in pediatric femoral neck fractures is 1%.^[11,21,22] In our study, there was no case of infection.



Fig.4 : Image A shows loosening of the implant. B shows stuck lag screw during implant removal. C shows non-union at 14 months follow-up.

Pinto et al.^[20] suggested that anatomic reduction, either by closed or open technique and adequate stabilization of the fracture are important for minimizing the risk of complications. There are some controversies regarding whether closed reduction is better over open and vice-versa. In our study, we initially tried closed reduction in all the cases regardless of whether the fracture is displaced or undisplaced and open reduction was done only when closed reduction failed. We believe that anatomic reduction of such fractures, be it through open or closed means is of utmost importance for a satisfactory outcome in the long run.

We applied fibular strut graft in 50% of our cases. In fresh cases where we could achieve anatomical reduction and adequate compression with our implant, we did not put the graft. However, in cases which presented relatively late or where there was delay in surgery, in cases of fracture comminution, and in

higher age group children with adequate space for grafting, we applied the graft. Outcomes were 'satisfactory' in 4 out of the 5 cases.

There were some limitations in our study. Small sample size was one of them. Average follow-up period was less.

V. CONCLUSION

Pediatric femoral neck fractures are rare fractures and associated with many complications, AVN being the most dreadful. Early active intervention with anatomical reduction and stable fixation helps in minimizing these complications. Pediatric dynamic hip screw can be used as a preferred implant of choice in 7-15 years age group as were in our study with 80% satisfactory outcomes. Use of fibular strut graft is advisable.

However, parents should be counselled regarding the chance of development of AVN in the long run and hence they should be encouraged to follow-up periodically.

CONFLICT OF INTEREST- No potential conflict of interest relevant to this article was reported.

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Dr. Kaushik Kumar Dutta, et. al."Functional Outcome of Dynamic Hip Screw in Pediatric Femoral Neck Fractures: An Institutional Five-Year Study." *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)* 22(4), 2023, pp. 41-47.

"Functional Outcome of Dynamic Hip Screw in Pediatric Femoral Neck Fractures: An Institutional Five-Year Study." *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)* 22(4), 2023, pp. 41-48.