Does the timing of treatment affect complications of pediatric femoral neck fractures?

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ABSTRACT

Objectives: Pediatric femoral neck fractures were reviewed to compare complications with the time of presentation.

Methods: 34 pediatric femoral neck fractures were studied to detect union time, avascular necrosis, premature physis fusion, and the neck-shaft angle. All complications were comparable between both groups.

Results: The mean union time was more in late presented group. Four children developed AVN. The neck shaft angle and pre mature fusion of growth plate were same in both groups.

Conclusions: The frequency of the complications except union time in pediatric neck femur fracture is comparable in early and late presented groups.

1. Introduction

Fracture neck of femur in the pediatric population accounts for less than 1% of all fractures.^{1,2} Only a high-energy injury can produce enough force to break the pediatric femur neck. It is imperative to do early diagnosis and prompt treatment of pediatric femoral neck fracture to reduce complications, which include avascular necrosis (AVN), non-union, coxa-vara and premature physis closure.³

The initial impact force, the age of the patient, type of fracture, displacement at the fracture site, timing of surgery and treatment modality may play an important role in the outcome. The timing of surgery and the treatment modality are the only surgeon-dependent variable.^{4,5}

Early reduction and stabilization of the fracture have shown lesser complications.^{4,6,7,8} Though, some authors believe that AVN is not influenced by the timing of surgery.^{9,10} It is not an uncommon scenario to have children with neck femur fracture presenting late. Aim of the study is to compare the union time and frequency of complications in children who presented early (less than 24 h) following injury with children who presented later (more than 24 h).

2. Materials and methods

A series of consecutive children from 2006 to 2016 presenting with femoral neck fractures in two tertiary-care centers were studied.

Consents were taken for the participation in the study. All the children were less than 17 years.¹¹ Their clinical and radiological details were retrieved from the medical records. We included the children with minimum 2-year follow-up period from the surgery. Children with polytrauma were included. Children with established non-union, pathological fractures and presented after two months were excluded.

Thirty-two children with 34 hip fractures formed the basis of the study. There were 24 boys and eight girls. The mean age of the children at the time of fracture was 11.71 ± 3.88 years (range: 4–17 years). Two children had bilateral femur neck fracture (Table 1). The mechanism of injury included road traffic accident in 10 children, fall from height in 20 children and generalized tonic clonic seizure in two children. Both children underwent blood investigations (RBS, Serum electrolytes, thyroid profile), and neurological evaluation with metabolic work up (Calcium, Vit D2, Alkaline phosphatase, PTH). No associated sign of rickets or metabolic bone disease were identified.

The cases were grouped into two categories depending on the duration between the injury and presentation to the hospital (less than 24 h and more than 24 h following injury). Fifteen children presented within 24 h following the injury to the hospital. They formed the early presentation group I. Seventeen children presented after 24 h following injury formed the late presentation group II (Table 1).

The fracture pattern was categorized into four types according to the classification proposed by Delbet and popularized by Colonna.¹² There were two patients with type I (*trans-epiphyseal fractures*), 16

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Table 1
Demographic data of pediatric femur neck fractures.

Variables		Group I ≤ 24 h	Group II > 24 h	N
Delbet types (N = number of femur heads)	Type I	0	2	2
	Type II	6	10	16
	Type III	9	4	13
	Type IV	1	2	3
Age at fracture (N = number of patients)	≤ 10 years	5	3	8
	> 10 years	10	14	24
The mean age at fracture (years)		10.44 ± 4.36	12.83 ± 3.09	
Gender (N = number of patients)	Boy	10	14	24
	Girl	5	3	8

patients with type II (*trans*-cervical fractures), 13 patients with type III (cervico-trochanteric fractures) and three patients with type IV (inter-trochanteric fractures).

All these children received treatment on an emergency basis with closed/open reduction and internal fixation (Table 2). The displacement and comminution at the fracture site were noted. The timing of the surgery, reduction technique, and union were noted. Two children had bilateral femoral neck fractures. Six children who were less than 6 years at the time of fracture were managed with an additional hip spica cast. Children older than 6 years were managed in crutches with non weight bearing for 6 weeks and weight bearing was initiated only, when radiological evidence of union at fracture site was noted.

The children were followed up at six weeks interval until the fracture united. Antero-posterior and frog-lateral views of radiograph were taken during each follow up to assess healing and subsequent complications. The union was defined by the absence of pain and continuation of the cortices in both views of the radiographs. Failure to unite by six months was considered as non-union. Once the union was complete, children were followed up at 3 months, 6 months and each year after that. All serial radiographs were evaluated for union timing, AVN and premature fusion of femoral capital physis.

2.1. Statistical analysis

Statistical package for social sciences software for Windows SPSS version 20.0 was used for statistical analysis. The time required for union of fractured neck femur and the neck-shaft angle was compared between the groups using Independent 't' test.

3. Results

Thirty-two children (34 hips) were included in this study. The mean age of 15 children in group I and 17 children in group II were 10.44 ± 4.36 years and 12.83 ± 3.09 years respectively. Both the groups were comparable for the number of participants and age of the children. The time of union and complications are described in Table 3.

Table 2
Internal fixation devices used in pediatric femur neck fractures.

Variables		Implants used				
		k-wire and hip spica	2 cannulated cancellous screws	3 cannulated cancellous screws	Dynamic hip screw	Locking compression plate
Age (years)	0–6	4	2	0	0	1
	6–12	0	6	4	0	1
	> 12	0	2	9	4	1
Delbet types	Type I	2	0	0	0	0
	Type II	0	4	12	0	0
	Type III	2	6	1	2	2
	Type IV	0	0	0	2	1

Table 3
Union time and complications following pediatric femur neck fracture.

Union and complications	Group I ≤ 24 h	Group II > 24 h	P
Mean union time (weeks)	12.37 ± 7.06	19.00 ± 17.03	0.021
Neck-shaft angle (degrees)	139.27 ± 9.67	137.43 ± 11.30	0.56
Avascular necrosis of femur head	2	2	–
Premature physis fusion	8	7	0.93

3.1. Union of fracture and union time

All fractures got united at final follow up (Fig. 1, Fig. 2). The mean union time in the group I children was 12.37 ± 7.06 weeks, and group II was 19.00 ± 17.03 weeks (Table 3). The difference of union time between both groups were statistically significant. Four children took more than 6 months for the union; of these, two children took more than a year for the union. Three were boys and one girl. No pain or implant failure was noted in these four children. No additional procedure was performed in these four femur neck fractures.

One boy with Delbet type III fracture of left femur neck presented within 24 h to the hospital. The fracture was reduced and fixed with dynamic hip screw system and a derotation screw. The fracture got united in 32 weeks. Reduction at the fracture site was poor with a gap of 3.5 mm at the calcar region.

Other three children presented late; two boys with Delbet type II fracture and a girl with Delbet type III fracture. The 16-year boy with Delbet type II fracture of the right femur neck presented 5 days after the injury. The fracture was fixed with three cannulated cancellous screw. The fracture got united in 62 weeks which was the maximum duration for healing in this series. This child has factor XIII deficiency. The reduction of the fracture was inadequate with rotation and 8° valgus at the fracture site. The head of the femur developed avascular necrosis (Fig. 3).

The Delbet type III fracture neck of right femur in the 11 years girl united in 58 weeks. There was comminution at the fracture site. The reduction was good, but immobilization was inadequate. Progressive varus could be seen in the follow-up radiographs. The neck-shaft angle was 116.34° on the right side compared to 121.99° on the normal side. There was no sign of avascular necrosis or premature physis fusion.

Seventeen-year boy presented with Delbet type II fracture of the right femur neck after 1 day from the injury. The fracture site had comminution. Inadequately reduced fracture was fixed with three cannulated cancellous screws. Follow-up radiographs showed collapse at the fracture site resulting in coxa-breva. The fracture got united in 40 weeks without AVN and any additional intervention.

3.2. Avascular necrosis

Avascular necrosis was noted in four children. All children were above 10 years and had delbet type II fracture. They all presented with groin or hip pain and limited range of motion within 8 months except

Fig. 1. Radiographs of 12-year-old child presented within 24 h after injury (a, b). Follow-up at 6 weeks (c, d), 14 weeks (e, f) and 2 years (g, h) show sound union of the fracture without complication.

Fig. 2. Radiograph of 16-year-old child presented after 24 h following injury (a, b). Follow-up at 5 weeks (c, d), 14 weeks (e, f), 20 weeks (g, h) and 2 years 10 months (i, j) show sound union of the fracture without complication.

one girl who presented after 2.5 years. One child having delayed union had AVN (described in previous section). Eleven years boy presented with Delbet type II fracture of the right femur after falling from height within 24 h from injury. The fracture was fixed using three cannulated cancellous screws. Though the fracture united in 12 weeks, head of the femur developed AVN (Fig. 4). Another 14 years boy presented with bilateral Delbet type II fracture neck femur 6 days after injury. Both fractures united in 12 weeks. However, the left femur head developed AVN. A fifteen-year girl had Delbet type II fracture neck of the left femur. She had an early presentation to the hospital and the fracture united in 12 weeks. She complained of groin pain and activity related pain in affected hip after 2.5 years of primary surgery. She had already undergone implant removal 1 year back and was evaluated using MRI which showed focal medial femoral head AVN (Ratlift Type II).

3.3. Coxa vara and premature physis fusion

The mean neck-shaft femur angle was $138.3 \pm 10.44^\circ$ on the affected side compared to $139.55 \pm 10.19^\circ$ on the normal side. The neck-shaft angles were comparable on both sides. Premature closure of

proximal femur physis was seen in eight femurs with early presentation and seven femurs with late presentation. Premature physis fusion was more commonly seen with Delbet type II fractures. All the physis except one having premature fusion was crossed by implant during fixation of the fracture. Only two physis which showed normal changes at the final follow up were crossed by implant during the fixation of the fracture.

Discussion.

The pediatric femoral neck fracture is known for complications rather than incidence. The age of the child, mechanism of the injury and type and character of fracture play important role in the outcome. The surgeon does not have control over the time of presentation but the time of surgery. Timely intervention in the form of accurate reduction and adequate stabilization and immobilization remains the mainstay of the treatment. Over the years, surgical intervention has increased for this type of fracture. The appropriate time for intervention is still a dilemma. The frequency of complications varies in the literature (Table 4).

Avascular necrosis may result in the collapse of the femur head and degenerative arthritis. The incidence varies in literature.¹³ Shrader treated 15 femur neck fractures within 24 h of injury. None of them

Fig. 3. Radiographs of 16-year-old boy with factor XIII deficiency presented 5 days from injury (a, b). Follow-up at 6 weeks (c, d) show maintenance of reduced fracture. At 62 weeks (e, f) the fracture has united. The final follow-up (g, h) shows AVN of the anterior part of the femoral head.

Fig. 4. Eleven-year-old child presented early with Delbet type II fracture (a). Post-operative radiograph shows valgus reduction (b). The fracture united in 12-weeks. Femoral head showed AVN, coxa-breva and premature physis fusion at 2-year (c).

developed AVN. Two of the five patients treated by him 48 h after injury developed AVN. He stressed on better reduction and use of newer implants to reduce the incidence of AVN.⁷ Our series had an incidence of 11.76%. Two fractures were treated within 24 h and two after 24 h. The reduction was anatomical in two patients and acceptable in two patients.

Head of the femur has a precarious blood supply. The high energy of trauma produces a significant displacement and comminution at the fracture site. Also, the affection of the lateral epiphyseal artery at initial impact worsens the prognosis by increasing the chance of AVN. The single confounding factor responsible for AVN is still a mystery. The timing of surgery and Delbet type I fracture are considered important factors for AVN.⁵ Delbet type I and type II fractures in an older child are prone to AVN.¹⁰ All patients in this series with AVN had Delbet type II injury and were older than 10 years. Also, there was no association between the time of presentation and AVN similar to the findings of Patrick et al.⁹ The initial impact of injury, age of the patient and extent of fracture remains the factors responsible for AVN.¹⁰

Non-union and delayed union are common complications of fracture neck of femur. Non-union can be defined as absence of signs of fracture healing at 6 months from injury.²⁸ Studies have shown good results in patients with non-union. In this series, all the fractures got united. The fractures in children who were treated early healed in 12.37 ± 7.06 weeks compared to 19.00 ± 17.03 weeks in the late presentation group ($p < 0.05$). The fracture healing was delayed in late presented group. Children older than 10 years took longer time for union of the fracture. The maximum time taken for the union was seen in a child with factor XIII deficiency. The fracture pattern, comminution at the fracture site, inadequate reduction, improper immobilization and implant failure can be attributed in the delay of healing.

Coxa-vara is a common complication seen in fracture neck femur.^{15,17} The incidence of coxa-vara can be controlled using

anatomical reduction and internal fixation.¹⁷ The neck-shaft angle of the healed fracture was comparable to the normal hip in this study.

Premature physis arrest can occur in Delbet type I and type II fractures especially when the implant crosses the physis. Ratliff reported premature physis fusion in 6.5% fractures, Morsy in 38% and Bombaci in 63.3%.^{16,17} Proximal femur physis prematurely fused in 15 neck fractures in present series; mainly in Delbet type II fracture. All these physes except one was penetrated by implant used for fracture fixation. Premature physis arrest was not affected by the timing of surgery. Smooth K-wires used in two Delbet type I fractures did not cause premature physis fusion. Physis was breached in these children to obtain a stable fixation.

Comminution at the fracture site, inadequate reduction and inadequate fixation of the fracture delays timely union. Premature physis arrest can be expected if physis is penetrated by screw during fracture fixation.

4. Conclusion

The frequency of the complications in pediatric neck femur fracture is comparable in early and late presented groups. The delayed union can be expected with late presented cases. Anatomical reduction and stabilization reduces the time of healing in fracture neck of femur in children. The frequency of AVN and other complications in femur neck fracture in children is independent of the timing of surgery. The complications may be related to the severity of the injury. The surgeon must consider an anatomical reduction and fixation of pediatric neck femur irrespective of late presented cases.

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Table 4
Complications following pediatric femoral neck fractures.

Sl.no	Authors	Year	N	Complications				
				AVN ^a	Non-union	PPF ^b	Coxavara	Others
1	Ingram AJ et al. ¹³	1953	24	6	Nonunion-3 Delayed union-1	–	2	Infection-1
2	Ratliff AHC et al. ¹⁴	1962	71	33	Nonunion-7 Delayed union-17	11	14	–
3	Canale T et al. ¹⁵	1977	61	26	4	33	11	Arthritis-16
4	Ng GPK et al. ¹⁶	1996	32	9	–	2	4	–
5	Morsy HA ¹⁷	2001	37	21	19	20	19	Shortening-29 Coxa valga-5 Arthritis-18 Infection-12 Coxamagna-1 Coxavalga-2 Shortening-7 Arthritis-2
6	Togrul E et al. ¹⁸	2005	63	9	1	5	5	Shortening-8 Coxamagna-1 Coxavalga-1 Refracture-1
7	Moon ES et al. ¹⁰	2006	25	2	1	–	1	–
8	Bombaci H et al. ⁵	2006	22	12	Nonunion-1 Delayed union-1	14	3	–
9	Shrader MW et al. ⁷	2007	20	2	–	–	–	Shortening-1
10	Varshney M et al. ¹⁹	2009	21	3	–	1	–	Shortening-2
11	Inan U et al. ²⁰	2009	9	4	–	–	–	–
12	Ahmed S et al. ²¹	2009	15	9	–	–	2	–
13	Eberl R et al. ²²	2010	22	2	–	–	1	Loss of reduction-12
14	Dendane M et al. ³	2010	21	6	1	–	5	Shortening-4 Osteitis-1
15	Song K ²³	2010	27	2	2	–	2	–
16	Hajdu S et al. ²⁴	2011	8	1	–	–	2	Shortening-3
17	Kuo FC et al. ⁸	2011	23	11	–	11	3	Coxavalga-2 Shortening-14
18	Bali K et al. ²⁵	2011	36	7	3	1	3	Arthritis-3 Infection-1 Screw perforation-1
19	Panigrahi et al. ²⁶	2015	28	4	2	–	2	Implant failure-1
20	Riley PM et al. ⁹	2015	22	6	–	–	–	Shortening-2
21	Ju L et al. ²⁷	2016	58	11	1	–	3	–
22	Our study	2019	34	4	4	15	–	–

^a Avascular necrosis of head of femur.

^b Premature physis fusion.

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Author contribution

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Kumar Amerendra Singh, Vidyasagar Chandankere and Hitesh Shah. The first draft of the manuscript was written by Kumar Amerendra Singh and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Declaration of competing interest

The authors declare that they have no conflict of interest.

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