

Pediatric Femoral Neck Fractures: Our 10 Years of Experience

Kamal Bali, MS, Pebam Sudesh, MS, Sandeep Patel, MS,
Vishal Kumar, MS, Uttam Saini, MS, M. S. Dhillon, MS

Department of Orthopedics, Postgraduate Institute of Medical Education and Research, Chandigarh, India

Background: Femoral neck fractures are rare injuries in children, but the high incidence of long term complications make it an important clinical entity. The aim of this retrospective study was to analyze the clinical outcomes of pediatric femur neck fractures that we managed over a 10 year period.

Methods: The study included 36 children (20 boys and 16 girls) who sustained femoral neck fractures and completed a minimum follow-up of one year. The children were treated either conservatively, or by open reduction and internal fixation (ORIF), or closed reduction and internal fixation (CRIF). The outcomes were analyzed using Ratliff criteria and a detailed record of complications was kept for all patients.

Results: The mean age of included patients was 10 years (range, 3 to 16 years) and the average follow-up was 3.2 years (range, 1.1 to 8.5 years). Based on Delbet's classification system, there were 0 type I (transepiphyseal), 16 type II, 11 type III, and 9 type IV fractures. There were 8 undisplaced fractures, 4 of which later displaced after being managed initially in a hip spica. A satisfactory outcome was obtained in 27 (75%) children. Avascular necrosis (AVN) was the most common complication. It was seen in 7 of our patients, all of whom had an unsatisfactory outcome. Other complications included three cases each of coxa vara, non-union, and arthritic changes; and one case each of infection, primary screw perforation of head, and premature epiphyseal closure. Complications were lowest in the group treated by ORIF. Only 2 patients managed exclusively by conservative treatment ultimately achieved a satisfactory outcome.

Conclusions: We believe that internal fixation of pediatric femoral neck fractures is preferred whenever feasible because conservative treatment carries a high risk of failure of reduction. Aggressive operative treatments aimed at anatomical reduction should be the goal and there should be no hesitation in choosing ORIF over CRIF. Outcome of patients is influenced primarily by development of AVN which occurs as an independent entity without much relation to the mode of treatment carried out.

Keywords: *Pediatric femur neck fracture, Avascular necrosis, Open reduction and internal fixation, Ratliff, Delbet classification*

Pediatric femur neck fracture is exceedingly rare and accounts for fewer than 1% of all pediatric fractures.^{1-5) Meyer⁶⁾}

attributed this low incidence to the thick and strong periosteum cover and to the tough strong bone of children. As

a result, most of these fractures (80% to 90%) are due to high-energy trauma. Despite their rarity, these fractures are associated with high rates of coxa vara, delayed union, and nonunion, especially in patients treated without internal fixation. Other complications, including osteonecrosis, premature physeal closure and limb length discrepancy, also occur and are more common with operative treatments.

The anatomy of the pediatric hip differs from that of adult hips. This difference accounts for differences in complications. Pediatric patients cannot be just treated

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Correspondence to: Kamal Bali, MS

Department of Orthopedic Surgery, Postgraduate Institute of Medical Education and Research, Chandigarh 160012, India

Tel: +91-9872448458, Fax: +91-172-2744401

E-mail: kamalpgi@gmail.com

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as “little adults”. A thorough understanding of anatomy is important to ensure proper treatment and to understand associated complications. Proper primary treatment of this hazardous fracture is the key to a successful outcome. We share our experience and understanding of this fracture by retrospectively reviewing our 36 cases and critically analyzing the complications and treatment received. The modes of treatment we review here are internal fixation by either closed or open means, and conservative management in spica.

METHODS

We retrospectively reviewed all children (less than 16 years old) with femoral neck fracture managed in our department from May 1998 to December 2007. A total of 36 children (20 boys and 16 girls) who completed a minimum follow-up of at least 1 year were included in the study. A written consent for participation in this retrospective study was obtained from the parents of all patients whom we were able to contact at the time of drafting the study.

The fractures were classified according to the Delbet system as popularized by Colonna⁷ and were further subdivided into displaced and undisplaced. The treatment modalities used were conservative management, open reduction and internal fixation (ORIF), or closed reduction and internal fixation (CRIF) depending upon the patient profile and the fracture pattern.

Assessment of the final outcome was made at the last follow-up visit using the Ratliff's method (Table 1).¹⁾ A good outcome was rated as a “satisfactory outcome” and fair and poor outcomes or the presence of complications were rated as an “unsatisfactory outcome”. Radiographs

were also evaluated for joint congruency, arthritic changes, neck-shaft angle, and avascular necrosis (AVN), which was further classified according to the Ratliff classification system (Table 2).

RESULTS

The mean age of included patients was 10 years (range, 3 to 16 years) with 20 males and 16 females. The average follow-up was 2.7 years (range, 1.1 to 9.5 years). The mechanisms of injury varied, with road traffic accident (RTA) being the most common etiological factor (19 patients). Of these 19 children, three sustained their injury as a pedestrian while the other 16 sustained their injury as a passenger in a motor vehicle (car or bus or motorcycle). Fall from height accounted for 13 cases, injury sustained due to a fall during playing accounted for 3 cases and a bull attack accounted for one case. To our surprise, there were only 14 children with isolated fractures of the femoral neck. The remaining 22 children had documented associated injuries (Table 3).

Sixteen cases (44.5%) were of Delbet type II (transcervical), eleven cases (30.5%) were of Delbet type III (cervicotrochanteric), and nine cases (25%) were of Delbet type IV (intertrochanteric). These fractures were further classified as displaced (28 cases) and undisplaced (8 cases). There were no cases of Delbet type I (transepiphyseal separation) in our study.

Conservative treatment with either skin traction (one patient) or hip spica was given initially to 13 patients. This group included all 8 of the undisplaced fractures. Five patients with displaced fractures were also treated conservatively after manipulative reduction because the children

Table 1. Ratliff System of Clinical and Radiographic Assessment

Good	Clinically, no or negligible pain, full or minimal restrictive hip movement, and normal activity or the avoidance of games. Normal or some deformity of the femoral neck in the radiograph.
Fair	Clinically, occasional pain, hip movement restriction less than 50%, and normal activity or the avoidance of games. Severe deformity of the femoral neck, mild avascular necrosis in the radiograph.
Poor	Clinically, disabling pain, hip movement restriction more than 50%, and restricted activity. Severe avascular necrosis, degenerative arthritis, arthrodesis in the radiograph.

Table 2. Ratliff's Classification of Avascular Necrosis (AVN)

Type 1	Diffuse increased density of the proximal fragment, accompanied by total collapse of epiphysis.
Type 2	Segmental involvement of femoral head, minimal collapse of epiphysis.
Type 3	Metaphyseal AVN, changes confined to femoral neck, excluding the epiphysis.

were sick due to multiple injuries and were not medically fit for surgery. However, 4 of these fractures got displaced again and ultimately required operative treatment once the general condition of the patient improved. There were 4 patients with initially undisplaced fractures that later displaced, even in the hip spica, and ultimately required operative fixation.

Displaced fractures were treated either by CRIF under fluoroscopy or by open reduction if closed anatomical reduction failed. Eighteen patients were treated by ORIF. Of these, 14 were fixed initially and 4 patients were those who failed conservative treatment. Eleven patients were treated by CRIF. Of these, 4 patients had failed initial conservative treatment. Treatment options used in all the patients are summarized in Table 4.

Table 3. Associated Injuries in 22 of the 36 Patients

Injury	No. of cases
Head injury including transient loss of consciousness	13
Facio mandibular injury	4
Chest injuries	2
Blunt trauma abdomen	5
Pelvic fracture	3
Distal radius fractures	2
Supracondylar fracture of humerus	1
Forearm fractures	1
Proximal humerus fractures	2
Clavicle fracture	2
Femur shaft fracture	1
Calcaneum fractures	1

Implants used for osteosynthesis depended on the operating surgeon's preference and the age of the child. These included either 6.5 mm partially threaded cancellous screws (PTCS) (Fig. 1), 4.5 mm PTCS, or the pediatric dynamic hip screw (DHS) (Fig. 2). The pediatric DHS was preferred in older children, especially those with Delbet type IV fractures.

Using the Ratliff's method, 27 patients had satisfactory outcomes (75%). Nine patients had unsatisfactory outcomes (25%) (7 poor and 2 fair). Of the 9 unsatisfactory results, 7 were due to AVN and one was due to deep infection of the hip which ended in septic sequelae with arthritic changes. Three patients ultimately required valgus osteotomy for non-union/coxa vara. In all, there were 19

Table 4. Management of the Cases Based on the Delbet Classification and Displacement of the Fracture

Delbet type	Conservative	ORIF	CRIF
Type II			
Displaced	2	10 + 2*	2
Undisplaced	2	-	1*
Type III			
Displaced	3	2 + 1*	3 + 1*
Undisplaced	3	-	1*
Type IV			
Displaced	-	2	4
Undisplaced	3	1*	1*
Total	13	14 + 4*	9 + 4*

ORIF: open reduction and internal fixation, CRIF: closed reduction and internal fixation.

*Denotes those cases which were initially managed conservatively and later operated as the reduction was lost.



Fig. 1. Displaced femoral neck fracture in a patient managed with open reduction and internal fixation using partially threaded cancellous screws.



Fig. 2. Displaced femoral neck fracture in a patient managed with open reduction and internal fixation using pediatric dynamic hip screw showing union in follow-up radiographs.

Table 5. Summary of the Complications Seen in the Study

Delbet type	No. of patients	No. of complications	AVN	Coxa vara	Nonunion	Premature epiphyseal closure	Arthritis	Infection	Primary screw perforation of head
Type II, displaced	14	8	3		1	1	2	1	
Type II, undisplaced	2	4	1	1	1		1		
Type III, displaced	8	4	2	1	1				
Type III, undisplaced	3	1		1					
Type IV, displaced	6	2	1						1
Type IV, undisplaced	3	0							
Total	36	19	7	3	3	1	3	1	1

AVN: avascular necrosis.

complications (Table 5) in 12 patients (7 AVN, 3 coxa vara, 3 non-union, 3 arthritic changes, and 1 case each of infection, primary screw cut out of the head, and epiphyseal perforation by the screw that ultimately led to premature epiphyseal closure) (Fig. 3).

Of the 7 patients who developed AVN, 6 were of Ratliff type I AVN with global involvement. There was one patient who developed Ratliff type II AVN. Four cases of AVN occurred in Delbet type II fractures (25% rate of AVN), two occurred in type III fractures (18% rate of AVN), and one occurred in a type IV fracture (11% rate of AVN). Three cases had arthritic changes of which two were a sequelae to AVN and one to infection.

The group in which ORIF was done had fewer complications (Table 6). These included three cases of AVN (one of these three cases was initially managed conservatively and later by ORIF) and one case of perforation of the head by the lag screw of the pediatric DHS. Of the 13

patients treated conservatively, reduction was lost in eight cases (62%) of which four patients subsequently underwent ORIF while the other four were managed by CRIF. There was one case of AVN and two cases of coxa vara in the patients managed conservatively. Of the 13 patients treated by CRIF, three patients developed AVN (one of these was initially managed by casting), 2 cases had non-union, and one developed coxa vara. These results are summarized in Table 6. Overall, there were fewer complications in patients treated by ORIF than in those treated conservatively or by CRIF.

DISCUSSION

Femoral neck fractures in children are always a result of high energy trauma because the femoral neck of children is dense and hard compared to adult femoral neck.⁸⁾ As a result, these fractures are usually associated with other

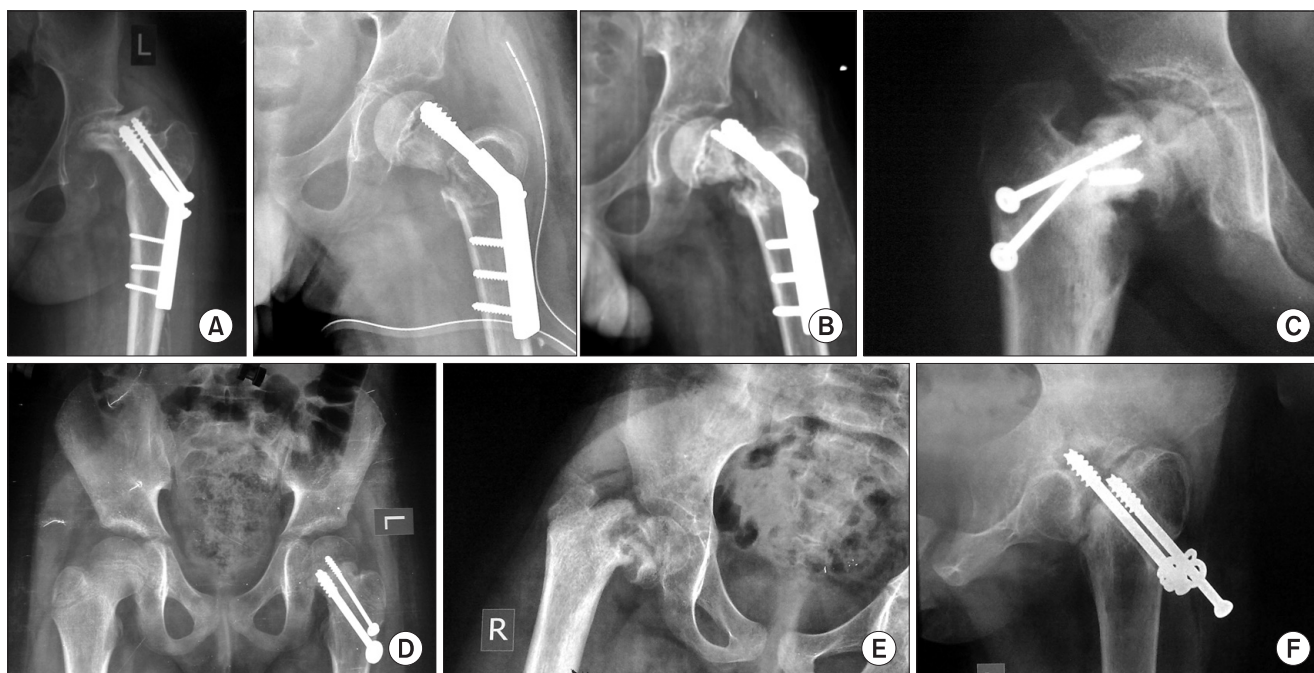


Fig. 3. Complications. (A) Avascular necrosis in a patient managed with pediatric dynamic hip screw. (B) Primary screw cut out immediately post operatively (left) with sequential radiograph (right) showing implant failure. (C) Implant breakage and varus in a patient managed with open reduction and internal fixation using partially threaded cancellous screws. (D) Perforation of the capital epiphysis by the screw. (E) Non-union with neck resorption after failed conservative treatment in hip spica. (F) Implant failure with head collapse.

Table 6. Summary of AVN, Coxa vara, Non-union, and Failed Reduction Seen in the Different Treatment Groups

Complication	Conservative	ORIF	CRIF
AVN	1	3	3
Coxa vara	2	0	1
Non-union	1	0	2
Failed reduction	8	0	0

AVN: avascular necrosis, ORIF: open reduction and internal fixation, CRIF: closed reduction and internal fixation.

concomitant injuries which should also be addressed. Although these fractures are relatively rare in children, the assumption of Hamilton²⁾ that an orthopedic surgeon might not see one of these fractures in a lifetime may not be true because of the high incidence of vehicular accidents in this era. In our study, 53% of fractures were due to RTA and 36% were due to falls from height. These data matched the incidence reported in the literature.¹⁻⁵⁾

As per the available literature, most of the large series on fractures of neck of femur in children⁹⁻¹¹⁾ report Delbet type II fractures as the most common, followed by

type III and type IV. Our findings also matched with this data (44.5% of our cases were type II, followed by 30.5% being type III and 25% type IV). Type I injuries (trans-epiphyseal) are very rare and we did not encountered any in our series.

The risk of AVN depends on several factors, including age, degree of initial displacement, type of fracture, time to surgery, and method of fixation.^{9,12-15)} The most important factor is likely the severity of vascular compromise sustained at the time of trauma. AVN develops in approximately 17% to 47% of the cases.^{9,11,16,17)} This is because the adult hip has intraosseous blood vessels that supply the femoral head, whereas the blood vessels of pediatric hip has cannot cross the open physis. Therefore, blood supply to the femoral head is critical in a child and can be disrupted easily by hip fracture.¹⁸⁾ As mentioned by Ratliff,¹⁾ the presence of AVN adversely affects the prognosis. In our study, the development of AVN contributed to 7 of the 8 (88%) unsatisfactory outcomes. The rate of AVN in our study was 19.4%, which was slightly less as compared to the previous studies.

Based on our results, we believe that internal fixation of pediatric femur neck fractures should be performed whenever feasible because conservative treatment carries a high risk of failure of reduction. Of the 13 cases treated

conservatively, 8 had a loss of reduction and ultimately required an operative intervention. This is not unexpected because of the inherent instability of these fractures. The femoral neck in children consists of smooth, hard, dense bone which does not have the typical adult trabecular pattern.¹⁹⁾ Fracture lines are often uniplanar (unlike spiral and triplanar in adults) and less jagged with very little interlocking patterns which makes these fractures highly unstable. Loss of reduction commonly occurs in traditionally applied hip spica. The pelvi-femoral muscles tend to pull the shaft in the cranial direction; as the spica is open at the top, it can never provide stability in this direction. Hence, an inherently unstable fracture (which is usually the case) is likely to redisplace in spica.

Out of the 5 patients who were exclusively managed by conservative treatment, 3 patients develop complications. Two of these patients developed coxa vara, with one of these having AVN in addition. The third patient had non-union. Thus, only 2 patients who completed conservative treatment had satisfactory results.

Coxa vara is a major complication leading to unsatisfactory results, as seen in the series of Lam¹¹⁾ and Ratliff.¹⁾ Our results matched these studies. However, the incidence of coxa vara is significantly lower in the series where internal fixation has been predominantly used. For persistent coxa vara, subtrochantric valgus osteotomy has been suggested and this has produced uniformly satisfactory results.^{16,20)}

Although non-union occurs in pediatric femoral neck fractures, the incidence is much less than in adults. The thick functional periosteum in children primarily accounts for this difference.⁴⁾ The primary cause of nonunion is inadequate reduction and most cases of non-union had occurred in displaced fractures.^{9,14,20)} We had 3 cases of nonunion with two from the group treated by CRIF. Of these 2 patients, one patient was Delbet type III displaced fracture who was initially managed in spica due to multiple associated injuries and was presented to us 14 days later with loss of reduction. The patient was treated CRIF using PTCS. However, the implant failed at 3 months follow-up with the patient having both coxa vara and non-union. The patient was later treated with subtrochantric valgus

osteotomy and ultimately had a satisfactory outcome.

The reported rate of infection is 1% in pediatric femur neck fractures.^{9,11,20)} We reported a single case of infection. Although the infection was ultimately resolved with three sequential debridement surgeries, the patient eventually developed an arthritic hip which led to an unsatisfactory outcome. We believe that a clean soft tissue dissection goes a long way is important in avoiding the potential complication of infection.

The results of our series suggest that children who underwent ORIF had fewer complications than other treatment groups. It is possible that orthopedic surgeons avoid ORIF in pediatric femur neck fractures for fear of disrupting vascular supply which may increase the risk of AVN. However, recent studies²¹⁾ report a decreased incidence of AVN in patients treated by ORIF. One possible reason for this might be the release of intracapsular pressure by capsulotomy.^{3,22-24)} Moreover, the lateral epiphyseal vessels course mainly along the femoral neck and not the capsule, and the anterior capsulotomy done for ORIF does not endanger the vessels which course in the neck.^{1,9,20)} Thus, we believe that ORIF achieves a good quality reduction which, in turn, reduces complications like non-union and coxa vara. We also believe that ORIF does not lead to increased incidence of AVN and that it is actually the initial trauma and the disruption of head vascularity that determines the likelihood of AVN in long run.

Although our experience limited to a small number of patients, we believe that femoral neck fractures in children need aggressive operative treatment aiming at anatomical reposition of femoral neck rather than conservative treatment. There should not be any hesitation to perform open reduction to achieve a stable anatomical reduction. These fractures still remain unsolved regarding AVN and it is of the utmost importance to inform at the outset.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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