

Femoral Neck Fractures in Children

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Sixteen cases of femoral neck fractures were treated at Shaikh Zayed Hospital during the last three years from 1986 to 1989 and results of treatment were reviewed in 15 cases. Patients were categorized in two main groups, those with fresh fractures (6) and those who presented late (10); either with varus deformity of the femoral neck (5) or with established nonunion (5). Using Ratliff's[4] criteria results were 100% excellent or good in fresh fractures and ununited fractures with varus deformity and 80% good results in established nonunion. No complications were observed in patients with fresh fractures but complication rate was high in fractures with varus deformity and those with nonunion. Shortening of the affected extremity from 1-3 cm was found in 100% of these fractures.

Fracture neck femur in children is a rare injury [1,2]. The rarity of this fracture is indicated by the scanty literature with few case reports on the subject. The initial case reports in the English literature were those of Barber in 1871, Crowel in 1885, and Whitmann in 1891 as cited by Tachdjian[2]. In 1951 Ingram and Bachynski studied 24 cases treated since 1930 by surgeons of the Campbell clinic in Memphis[3]. They noted that fracture neck of femur in children resulted from severe trauma and avascular necrosis was a serious complication. They advocated the treatment of the fracture with internal fixation of the fragments. Ratliff in 1962 reported a large series of 71 cases and later in 1981 he added 97 cases, a total of 168 cases and found avascular necrosis to be the most common complication[4,5]. Complications were most commonly found in displaced fractures (69%) than with fractures having no initial displacement (33%)[5]. Lam presented a personal series of 92 cases of femoral neck fracture in children and noted that displaced transcervical and cervicotrochanteric fractures remained an unsolved problem[6]. He found coxa vara the most common complication (32%) followed by avascular necrosis (17%) in patients seen early. Leung and Lam reviewed these 92 children in 1986 both clinically and radiologically, at 13-23 years after injury[7]. Early results had been excellent in these patients but later review showed an 83% incidence of radiographic

abnormality and 24% had pain, limp or leg shortening.

Purpose of this study is to evaluate the results of treatment of femoral neck fractures at Shaikh Zayed Hospital Lahore during the last three years.

MATERIAL AND METHODS

Sixteen cases of femoral neck fractures were included in this study who were admitted and treated at Shaikh Zayed Hospital during last three years from November 1986 to October 1989. Six of these were fresh fractures, and ten cases were recorded late. Out of the late cases, five fractures had varus deformity of femoral neck, and five established nonunion. Three of the patients who presented with varus deformity were initially treated by quacks. Two were treated with hip spica at other hospitals. All of these cases presented with pain, limp, shortening of the affected extremity and some limitation of movements of the injured hip. Five patients presented with established nonunion following femoral neck fractures. Three of these five had no treatment for a period of eight months to eight years. Two of these were treated inadequately elsewhere. Number of fractures in different groups of patients are given in table No. I.

Table 1:

Material and Methods

Fresh Fractures	6 cases
Late Cases	
Fractures with varus deformity	5 cases
Nonunion	5 cases

Fractures were classified according to Delbet classification cited by Colona[8] and adopted by Ingram and Bachynski[3], McDougall[9] and Ratliff[4]. Delbet's classification is as follows:-

Type I or transepiphyseal fractures

- A. Transepiphyseal fracture without dislocation.
- B. Transepiphyseal fracture with dislocation of femoral head.

Type II or transervical fractures

- A. Undisplaced.
- B. Displaced.

Type III or Cervicotrochanteric fractures

- A. Undisplaced.
- B. Displaced.

Of the six patients that presented early for treatment, one was intertrochanteric fracture, four cases were cervicotrochanteric fractures, and one transcervical fracture. No transepiphyseal fracture separation was noted. In the patients who presented late with varus deformity, there were three cervicotrochanteric or basal fractures and two transcervical fractures. In the patients who had nonunion or pseudarthrosis, previous radiographs showed three cervicotrochanteric fractures and two transcervical fractures. It is usually impossible to distinguish between transcervical and cervicotrochanteric fractures before reduction and examination of radiograph. Particularly lateral view is necessary to differentiate these fractures[5]. Three of the six fresh fractures were undisplaced and other three were displaced. Fractures were displaced in all patients with established nonunion. Fracture patterns and their numbers are shown in table No.2 & 3.

Table 2: Classification of Fractures

Patient Category	Type 1	Type 2	Type 3	Type 4
Fresh fractures	0	1	4	1
Late cases.				
Fractures with varus deformity	0	2	3	0
Non union	0	3	2	0

Table 3: Site and Nature of Fractures in 16 Patients

Fracture Type	Number	Percent
Transepiphyseal	0	
Transcervical	6	37.5
Cervicotrochanteric	9	56
Intertrochanteric	1	6.5
Displaced	13	81
Undisplaced	3	18

Age ranged from two to fifteen years in the total series with the average age 8.6 years. Four (25%)

patients were female and twelve (75%) were male. Left hip was affected equally as the right hip. Age and sex incidence of femoral neck fractures in children is given in the table No.4. Fractures with varus deformity had femoral neck to shaft angle ranging from 90 degrees to 100 degrees. All patients with varus deformity presented with limp and pain in the affected hip. They all had limitation of abduction and rotation movements, especially of internal rotation. The affected extremity was shortened about 2 to 3cms in all of these cases.

Table 4: Age and Sex Incidence.

Highest incidence was at the age of 6 years.	
Age	
Average age	8.6 years
Male	12 cases
Female	4 cases
Male : Female	3 : 1

Five patients with established nonunion or pseudarthrosis were found to have a limp. There was shortening of the affected extremity from 3 to 4cms and full range of movements of the involved hip was present but it was painful. Radiographs showed premature closure of epiphysis in all these cases. In three of these patients femoral neck was found to be almost completely absorbed with proximal migration of greater trochanter. One of these patients had the femoral neck absorbed in the posterosuperior region thus creating a gap between femoral head and upper part of neck.

Mechanism of Injury

The fracture was caused by severe violence in 15 (95.3%) out of 16 patients. The most common type of violence was fall from height, that included fall from roof, a wall, stairs, a tree or a sloping surface. Twelve (75%) out of 16 patients fell from height, only two (12.5%) patients were knocked over in traffic accident in contrast to the Ratliff series[5] who noted traffic accident to be the most common mechanism of this injury. The experience of Gupta and Chuturvedi et al[10] in India in general appears to be similar to our experience. In their cases fall from height resulted in the injury of 71% of the patients and only 12% sustained fractures of the neck of the femur in traffic accidents. Most of the children who sustained femoral neck fracture fell from height in Mc-Dougall's series[9].

The mechanism of injury in this series of 16 patient is summarized in table No.5.

Femoral Neck Fractures

Table 5: Mechanism of Injury

Type	Mechanism	No. of Patients
Severe	Fall from height	12 (75%)
	Traffic accident	02 (13%)
	Slipped while playing	01 (06%)
Mild	Slipped while walking	01 (06%)

Management in the Hospital

Pre operative Management

Bucks traction was applied to the affected extremity in patients with fresh fractures for immobilization in the preoperative period. Two of the five patients who had pseudarthrosis of the femoral neck with proximal migration of greater trochanter and shortening of the extremity were kept on skeletal traction applied through the proximal tibial pin for 7-10 days with 8-15 pounds of weight with out significant effect in pulling down the proximal fragment. Skeletal traction was not tried any more in the rest of the patients.

Operative Management

Fresh Fractures

Patients with undisplaced fractures, one intertrochanteric and two cervicotrochanteric fractures were given hip spica. Three displaced fractures were reduced closely under image intensifier on the fracture table. In the two patients internal fixation was done with two to three 6.5mm diameter cancellous screws and a side plate. In the third patient fracture was fixed with three cancellous screws only. Treatment of fresh fractures in our series is summarized in table No.6.

Table 6: Treatment of Fresh Fractures

Patient Category	Site & Nature of Fracture	Number	Treatment
Fresh Fractures	Undisplaced Type 3 (2) Type 4 (1)	3	Hip spica
	Displaced Type 2 (1) Type 3 (2)	3	Closed reduction & internal fixation

Fractures with Varus Deformity

In all of these patients fracture was fixed with 1-2 cancellous lag screws, a subtrochanteric valgifying prop ostetomy was done and fixed with a well contoured narrow dynamic compression plate. Summary of the treatment of fractures with varus deformity is given in Table No.7.

Table 7: Treatment of Fractures With Coxa Vara

Patient Category	Site & Nature of Fracture	Number	Treatment
Fractures with varus deformity	Type 2 (2)	5	Sub. Troch.
	Type 3 (3)		Val. osteotomy & internal fixation of fracture

Sub, Troch. = Subtrochanteric; Val. = Valgifying

Non United Femoral Neck Fractures

In three of these patients nonunion was fixed with two 6.5mm diameter cancellous lag screws passed through the well contoured narrow dynamic compression plate and a fibular graft taken from the ipsilateral leg was inserted into the femoral neck and head and then subtrochanteric prop valgifying osteotomy was done and fixed with the plate. One patient had his fracture fixed using cancellous screws with a side plate and with the addition of fibular graft in the lower part of femoral neck but without subtrochanteric valgifying osteotomy. In the fifth patient nonunion was fixed with cancellous screws, a side plate and subtrochanteric valgifying osteotomy was done but without fibular strut graft inserted into the femoral neck. Treatment of nonunited femoral neck fractures in our series is given in the table No. 8.

Table 8: Treatment of Nonunion

Patient Category	Site & Nature of Fracture	Number	Treat
Non-Union	Displaced Type 2 (3) Type 3 (2)	3	Int. fix. fracture & Sub. Troch. Val.osteotomy & fibular grafting
		1	Int. fix. fracture & fibular. grafting
	1	Int. fix. & Sub. Troch. Val.osteot	

Int. fix. = Internal fixation
Val. osteot. = Valgifying osteotomy
Sub. Troch. = Subtrochanteric

Operative Technique of Fracture Fixation, Fibular strut Grafting and Subtrochanteric Valgifying Osteotomy.

The patient was placed spine on a fracture table with the image intensifier in place. Feet were attached to the traction stirrups. If fracture was displaced closed reduction was carried out by applying longitudinal traction, abduction and internal rotation and was checked by image intensifier. After preparing the skin and draping, upper femur was exposed just distal to the greater trochanteric by a standard lateral approach. Anteversion pin was inserted parallel to the femoral neck. Then another 2.4mm diameter K-wire was inserted parallel to the anteversion pin. A 6.5mm diameter lag screw was used to fix the fracture. Then a guide wire was inserted into the femoral neck and head just above or below the previously inserted screw up to the subchondral region if the epiphyseal plate had already closed. Length of the fibular graft required was determined by measuring the length of the guide wire inserted. Required length of the fibular graft was taken from the middle third of the ipsilateral leg. Interosseous border of the fibula was nibbled off or was cut with a saw in the two thirds of its length to facilitate insertion into the femoral neck.

Channel for fibular graft was prepared with Dynamic Hip Screw Reamer (DHS Reamer) and fibular graft was hammered into the prepared channel over the guide wire and again its position was checked with image intensifier. For valgifying osteotomy a pre-operatively calculated laterally based wedge of bone was removed from the subtrochanteric region and was fixed with a well contoured Narrow Dynamic Compression Plate. Through the upper one or two holes in this plate screws were inserted which fixed the fracture of the femoral neck. Final position of the fixation system was checked. Bone obtained from the osteotomy cut was placed at the osteotomy site and wound was closed over a suction drain.

Post Operative Care

In cooperative patients hip spica was not applied after internal fixation of fracture or non union of femoral neck in children. Patients were kept non weight bearing on the affected extremity for a period of two to three months and then gradual weight bearing was started. All patients were followed regularly in out patient department.

COMPLICATIONS AND RESULTS

In the analysis of results we have used the criteria described by Ratliff[4]. According to these criteria if there is no pain, full range of movements, normal activity and normal radiographs, the results are rated as good. If there is occasional pain, greater than fifty percent range of movements, normal activity or patient avoids games and there is severe deformity of femoral neck or mild avascular necrosis of femoral head in the radiographs, the results are rated fair. When there is severe pain, less than fifty percent range of movements, restricted activity and severe avascular necrosis of femoral head or degenerative arthritis, the results are rated poor.

Fresh Fractures

All of these fractures were united in three to four months. All of these patients were pain free, with full range of movements of the affected extremity. They all were fully active and radiograph of the affected hip showed no abnormality when followed for the average duration of 6 to 8 months. The results in this group were rated as 100% good as shown in table No. 9.

Table 9: Assessment of Results

Patient Category	Good	Fair	Poor
Fresh Fractures	100%	0	0
Late cases.			
Fractures with varus deformity	100%	0	0
Established non union		80%	20 0

Fracture Neck of Femur Which Presented Late

Fracture Neck of Femur with Varus Deformity.

Average duration of follow up was five months in these patients. All of these fractures united and there was no pain or limitation of activity and the results were good in all of these five patients (100%) as shown in table No. 9. Complications noted were shortening of the affected extremity by 1-1.5cm in 100% of the cases and mild limitation of movements in 20% of cases as given in table No. 10 a & b.

Nonunion or Pseudarthrosis of the Femoral Neck.

Results were good in four (80%) of the five

Femoral Neck Fractures

patients and fair in the fifth (20%) as summarized in table No. 9. They had normal range of movements with no pain and normal activity. All of these patients had some shortening of the affected extremity ranging from 1-2.5cm. They all had premature fusion of capital femoral epiphysis pre operatively and shortening of the neck in four of the five cases. One case showed gap in the posterosuperior part of the femoral neck and segmental necrosis (type-II) of the femoral head epiphysis. One patient had relative over growth of greater trochanter with mild limp. Complications encountered in our patients are given in table No. 10 a & b.

Table 10.(a) Complications of Femoral Neck Fractures

Patient Category	Coxa Vara	Non Union	Pain & Limited Motion
Fresh Fractures	Nil	Nil	Nil
Late cases Fractures With Varus Deformity	Nil	Nil	20%(1/5)
Nonunion	Nil	Nil	20%(1/5)

Table 10.(b): Complications of Femoral Neck Fractures

Patient Category	Pre.Mature Ep. Closure	Leg Length	A.V.N
Fresh Fractures	Nil	Nil	Nil
Late cases Fractures with Varus Deformity	Nil	-1.5 cm Nil in 100%	
Nonunion	100%	-2-3 cm in 100%	Nil

We compared our results with other series as shown in table No.11. We were able to achieve good results in eleven, out of twelve displaced fractures, which are even better than Canale and Bourland series[11], who were able to get good results in twenty four out of forty eight displaced fractures.

Table 11: Comparison of Results of Displaced Fractures

Study	Good	Fair	Poor	Displaced Fractures
Ratliff (1962)	14	7	24	45/70 (64%)
Lam (1971)	19	16	5	40/75 (53%)
Canale and Bourland (1977)	22	12	14	48/61 (79%)
Present study (1989)	11	1	0	12/15 (80%)

We also compared our complication rate with those of others as shown in table No.12. Avascular necrosis rate in our series was 6.5% compared with forty three percent in Canale and Bourland[11] cases. Premature epiphyseal closure was noted in thirty three percent, coxa vara, thirty three percents, nonunion 6.7% as compared with Canale and Bourland series[11], who noted coxa vara twenty one percent, nonunion 6.5% and premature epiphyseal closure in sixty one percent of their cases.

Table No. 12. Comparison Of Complications

Study	AVN %	C.V. %	N.U. %	Prem. Ep. Closure %
Ratliff (1962)	42	-	10	9
Lam (1971)	17	32	13	20
Canale and Bourland (1977)	43	21	6.5	61
Present study (1989)	6.5	33	6.7	33%

AVN = Avascular necrosis

C.V. = Coxa vara

N.U = Non union

Prem.Ep. = Premature epiphyseal

DISCUSSION

Incidence of femoral neck fracture is very low in children[4,12]. We have also found 16 patients with femoral neck fracture in children in the last 3 years which is in accordance with the previous reports. Although femoral neck fractures can occur at any age in children these were more common from eight to ten

years of age as shown in our study and by Canale and Bourland[11].

Ratliff[4] and Tachdjian[2] found highest incidence of these fractures at the age of 11 and 12 years. In our study we have found higher incidence in boys than in girls a ratio of 3:1 as did Ratliff[5].

The most common cause of these fractures in our study was fall from height (75%), and this mechanism of injury is also stated by McDougall[9] to be the most common cause of hip fractures in children. Because these fractures occur as a result of severe trauma, about 30% of the patients have serious associated injuries[13]. Associated minor injuries were found in only one of our patients.

We found very low incidence of intertrochanteric fractures one in sixteen (6.5%) and no patient with traumatic separation of capital femoral epiphysis. Highest incidence of cervicotrochanteric fracture was found in our series. Ratliff found transcervical fractures to be the most common[5].

Coxa vara is a rather frequent undesirable result in the fracture of femoral neck in children and can occur with or without avascular necrosis or nonunion[3,14]. We encountered coxa vara in 5 of 16 cases. These were either not treated at all or were treated with hip spica before they came for treatment. McDougall[9] found a high rate (55%) of coxa vara in his reported cases. Lam[6] stated that coxa vara was the most common complication (32%) in his study but it was not found to be incompatible with good results. In coxa vara the trochanteric area is pulled upwards towards the ilium, this results in shortening of the extremity and weakening of abductors results in a marked Trendelenberg limp[5,14]. Coxa vara is a three dimensional deformity including upward pull, medial pull and external rotation of the femoral shaft. Medial shift results in an overall shortening of the femoral neck, and external rotation creates femoral neck retroversion. Hip spica cannot maintain reduction of the fragments because the displacing forces do not meet the side walls of the cast and coxa vara can result when femoral neck fracture is immobilized in hip spica[14]. Abduction and internal rotation with hip spica can maintain the reduction but this is not recommended because this increases the risk of avascular necrosis[15]. This shows that very few hip fractures in children can be treated effectively in hip spica. When a displaced or a potentially unstable fracture is reduced and is held in spica cast, coxa vara may still result[16].

Hardness of a child's bone and small size of femoral neck limits the accessibility of fixation devices.

Threaded pins or small caliber screws should be used but these must not cross the physis. In high transcervical or transepiphyseal fractures smooth pins fixation is the treatment of choice. Crossing the physis with threaded screws or pins increases the risk of premature epiphyseal fusion[4].

Displaced transcervical or cervicotrochanteric fractures are difficult to handle[6]. Closed reduction and internal fixation is the treatment recommended by different authors[3,5,17]. Most of them recommended Knowles pins fixation for these fractures. We believe that cancellous lag screw fixation with addition of side plate gives better results if crossing of epiphyseal plate by screw threads can be avoided. This can be easily achieved in cervicotrochanteric and in low transcervical fractures. Cannulated Asnis hip screws make the internal fixation easier[18]. Addition of side plate for fracture fixation has some advantages. Pins or screws without a lateral plate tend to converge in the head and loosening of pins or screws occurs at the level of lateral femoral cortex[19]. Loosening of the pins or screws may result in sagging of the femoral head if lateral plate is not used for fracture fixation, which binds tightly against the screws as the fracture is impacted.

This series differs from other series in treating and analyzing the results in five patients who developed nonunion as a result of unsatisfactory treatment or neglected fractures. For nonunion or pseudarthrosis of the femoral neck, we have found subtrochanteric valgifying osteotomy and fibular strut grafting along with compression fixation of the nonunion to be the satisfactory treatment. Eighty percent good results were obtained with this procedure. Carrel and Carrel[20], Ingram and Bachynsky[3] and Ratliff[4] found the incidence of nonunion from 10-15% of the cases reported. Ratliff[4] found that a primary subtrochanteric valgifying osteotomy had prevented nonunion. Purpose of this osteotomy is to shift the femoral shaft from adducted to abducted position so that the shearing stresses of weight bearing and muscle retraction becomes an impaction force[21]. Allende and Lezama[12] stated that in displaced ununited fractures when the Pauwel's angle was greater than fifty degrees, the use of fibular graft along with subtrochanteric osteotomy accelerated the process of consolidation.

Coxa vara was seen with ununited femoral neck fractures in five of our patients, these were either inadequately treated or neglected fractures. We did not see coxa vara in our patients treated for fresh fractures. The reason for this was that all the displaced fresh fractures were fixed after closed reduction, and only

Femoral Neck Fractures

undisplaced intertrochanteric or cervicotrochanteric fractures were treated with spica cast. All of these patients were followed regularly to detect early displacement. We did not observe any complication in patients with fresh fractures in the average follow up period of six to eight months. Longer follow up will be required to see any complication if it occurs. Leung and Lam[7], noted high complication rate at thirteen to eighteen years after the injury.

Leg shortening was seen in all the patients with ununited fractures either with varus deformity or established nonunion but it did not affect the function significantly in our patients. Premature epiphyseal closure and absorption of femoral neck was observed in all cases of nonunion. Avascular necrosis type 1 was seen in only one patient with nonunion, who was considered to have fair results. High complication rate in our patients with ununited fracture was due to lack of primary management or unsatisfactory initial treatment. Avascular necrosis of femoral head was noted in only one case(6%) out of sixteen patients. This may be due to short follow up period and the investigations like bone scan were not done to detect early avascular necrosis.

CONCLUSION

This study shows that hip fractures result from severe violence, mostly due to fall from height (75%). Results of treatment of fresh fractures are very encouraging if internal fixation is used after closed reduction of displaced fracture and hip spica cast for undisplaced cervicotrochanteric and intertrochanteric fractures. Nonunion of femoral neck can be managed by internal fixation combined with subtrochanteric valgifying osteotomy and fibular strut grafting. Varus deformity with ununited femoral neck fractures can be treated effectively by fixation of the fractures and subtrochanteric valgifying osteotomy. Number of patients in this study is small in each category of the patients and follow up period is also short to evaluate the final results and to give a line of treatment in these fractures.

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Ford's Principle of Human Dynamics

*If you think you can, you're right. If you think you can't, you're right again,
because you'll never be able to.*

Zumwalt Law of the Laboratory

*The probability of failure is directly proportional to the number and
importance of the people watching the test*