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Original Article

Does early stable fixation reduce complications in paediatric femoral neck fractures?

Asad Khan, Yasir S Siddiqui, Mohd Baqar Abbas, Mazhar Abbas, Julfiqar Mohd, Mohd Hadi Aziz

Department of Orthopaedic Surgery, J.N. Medical College, Faculty of Medicine, A.M.U., Aligarh, UP, India

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Abstract: The primary objective of this study was to juxtapose the union rate and incidence of complications in paediatric patients presenting early (≤ 7 days) following injury with children presenting later (> 7 days) with femoral neck fractures. This critical appraisal evaluated 15 patients according to their timing of presentation and surgery from the initial day of injury (Group A: operated ≤ 7 days or Group B: > 7 days of injury). Patients with traumatic femoral neck fractures with Delbet 1 to 4 subtypes who were skeletally immature (age ≤ 16 years) were included in the study. Pathological fractures and post-infective fractures were not included. Each patient's secondary loss of reduction was calculated by measuring the Neck shaft angle (NSA) on the immediate post-operative radiograph and at the union. A change in NSA of ≥ 5 degrees was considered a significant loss of reduction. Ratliff's Criteria was used to analyze the final result, and a thorough record of complications was kept. There were no significant variations in the two groups' with respect to distributions of age, sex, injury mechanism, or fracture pattern. The most frequent injury culprit in both groups was falling from a height. Type II fracture pattern (54.54%) was more common in group A, while Type III and Type II fracture pattern was equally distributed in group B. In group A, the mean operation time was 55 ± 8.25 minutes, whereas in group B, it was 65 ± 15 minutes (*p*-value > 0.05). In group A, 90.9% of patients underwent CCS fixation, and in group B, 75% underwent fixation by CCS. The quality of reduction in post-operative radiographs was anatomical in 10 (90.9%) patients and unacceptable in 1 (9.1%) patient. In group B, 2 (50%) patients had an anatomical reduction, while 2 (50%) patients had an unacceptable reduction. Timing of reduction and its association with complications showed that early stable reduction and fixation decrease the occurrence of complications in femoral neck fractures (*p*-value = 0.033). Fracture union was seen in all our patients in both groups and none of our patients underwent non-union. The mean union time was 11.11 ± 7.06 weeks in group A and 16.5 ± 2.59 weeks in group B (*p*-value = 0.0189). In group A, only 1 (9.1%) patient developed coxa vara. In group B, out of 4 patients, the femoral head of one patient underwent avascular necrosis, one patient exhibited coxa vara, and 1 patient developed premature physeal closure with limb length inequality. Management of femoral neck fractures in children is challenging because of the paediatric bone's peculiar anatomic and physiological considerations. In our study, patients operated within 7 days developed fewer complications as compared to patients who were operated after 7 days, which was statistically significant. Although AVN is a frequent adverse consequence of pediatric femoral neck fractures, early reduction and stable fixation lowers AVN rates, as observed in our study. Our short-term functional and radiological results using the Ratliff scoring system were comparable to previous studies owing to stable anatomic reduction. Based on our findings and the existing literature, we emphasize long-term follow-up and recommend an early stable anatomic reduction in the treatment of paediatric femoral neck fractures.

Keywords: Paediatric femoral neck fracture, neck shaft angle (NSA), avascular necrosis (AVN), coxa vara, ratliff's criteria, CCS (cannulated cancellous screws)

Introduction

Fractures involving the proximal femur epiphysis, femoral neck, or intertrochanteric portion of the femur are collectively referred to as paediatric femoral neck fractures, which account for approximately 1% of all childhood fractures [1-3]. Although these fractures are uncommon, children are susceptible to post-surgical delayed complications, such as premature physeal closure, avascular necrosis (AVN) of the femoral head, and coxa vara [1, 4]. These complications, in turn, could result in antalgic gait, a lifelong limp, and a limited range of motion attributable to the proximal femur's open physis in children and the vulnerable blood supply [5, 6] to the femoral head [1, 4, 7]. Among these adverse effects, AVN has been found to be an

important risk factor for hip arthritis; however, there is currently no effective treatment available [1]. High-intensity trauma is typically to be blamed for a neck femur fracture in children. Intra-abdominal, intra-pelvic injuries, and head injuries are the most commonly associated injuries [8]. Though fracture neck of the femur in the paediatric population is a rare injury in the Western world, it is relatively common in the Indian subcontinent and presents a management challenge because of variable functional outcomes due to associated post-surgical delayed complications. Numerous studies have demonstrated that children with femoral neck fractures should have fracture reduction and subsequent internal fixation within 24 hours [2, 9]. However, it might be challenging to stick to this deadline for a number of reasons, particularly in underdeveloped countries. Treatment delays in the surgical management of these fractures are more frequent in developing nations as a result of delays in presentation. The available literature on the best course of action for patients whose treatment is postponed due to delayed presentation is insufficient. Therefore, in this critical appraisal, we compare the functional outcome of surgical treatment of paediatric femoral neck fractures in children with early (≤ 7 days) and delayed (> 7 days) presentation from the time of injury.

Aims of study

The primary objective of the present study was to compare the incidence of complications and union rates in children presenting early (≤ 7 days) following injury with children presenting later (> 7 days). The secondary aim was to study the demography of paediatric femoral neck fractures.

Methods

Study design

This critical appraisal was conducted in the Department of Orthopaedic Surgery, J.N. Medical College, Aligarh Muslim University, Aligarh, UP, India. The study included paediatric patients with femoral neck fractures from November 2020 to October 2022. The study involved 15 patients who were grouped according to their timing of presentation and surgery from the initial day of injury. Written informed consent was obtained from each study participant after explaining the study's purpose. An approval from the ethical committee was obtained before they were included in the study (Ref No: IECJNMC/375).

Inclusion and exclusion criteria

Skeletally immature (age ≤ 16 years) patients with open proximal femoral physis, closed fractures, and traumatic femoral neck fractures having Delbet 1 to 4 subtypes were included in the study. Open/Compound fractures, pathological fractures occurring due to pre-existing metabolic disease or due to a pathological lesion in the proximal femur like a simple bone cyst, children with already fused proximal femoral physis, and post-infective fractures were excluded from the study.

Patient randomization and group allocation

The current study included 15 patients who met the inclusion requirements. Out of 15 patients, 11 patients were allocated group A (≤ 7 days) and 4 patients were allocated group B (> 7 days). The allocation of groups was done on the basis of the initial delay in the presentation of the patient to our OPD or emergency. Delayed presentation after sustaining an injury is a common problem in the Indian scenario. Although we tried to operate on the patients as soon as they got admitted with us, but due to delayed presentations, two groups were made according to their timing of operation from the initial day of injury. All research participants underwent extensive clinical and radiological examinations in accordance with the planned study protocol.

Surgical intervention and implant used

Ten patients in group A underwent closed reduction and internal fixation by cannulated cancellous screws (CCS) and 1 patient underwent closed reduction and fixation by paediatric DHS (dynamic hip screw). Three patients in group B underwent closed reduction and fixation by cannulated cancellous screws, and 1 patient underwent fixation by paediatric DHS. None of the study participants underwent an open reduction. **Figures 1-8** represent paediatric femoral neck fracture fixation in our study. All patients were given injectable antibiotics 30 minutes before the surgical incision. The anaesthetist made the selection regarding the type of anaesthesia to be given.

Quality of reduction [9]

All reductions were performed using the Whitman technique [10]. Reduction quality was

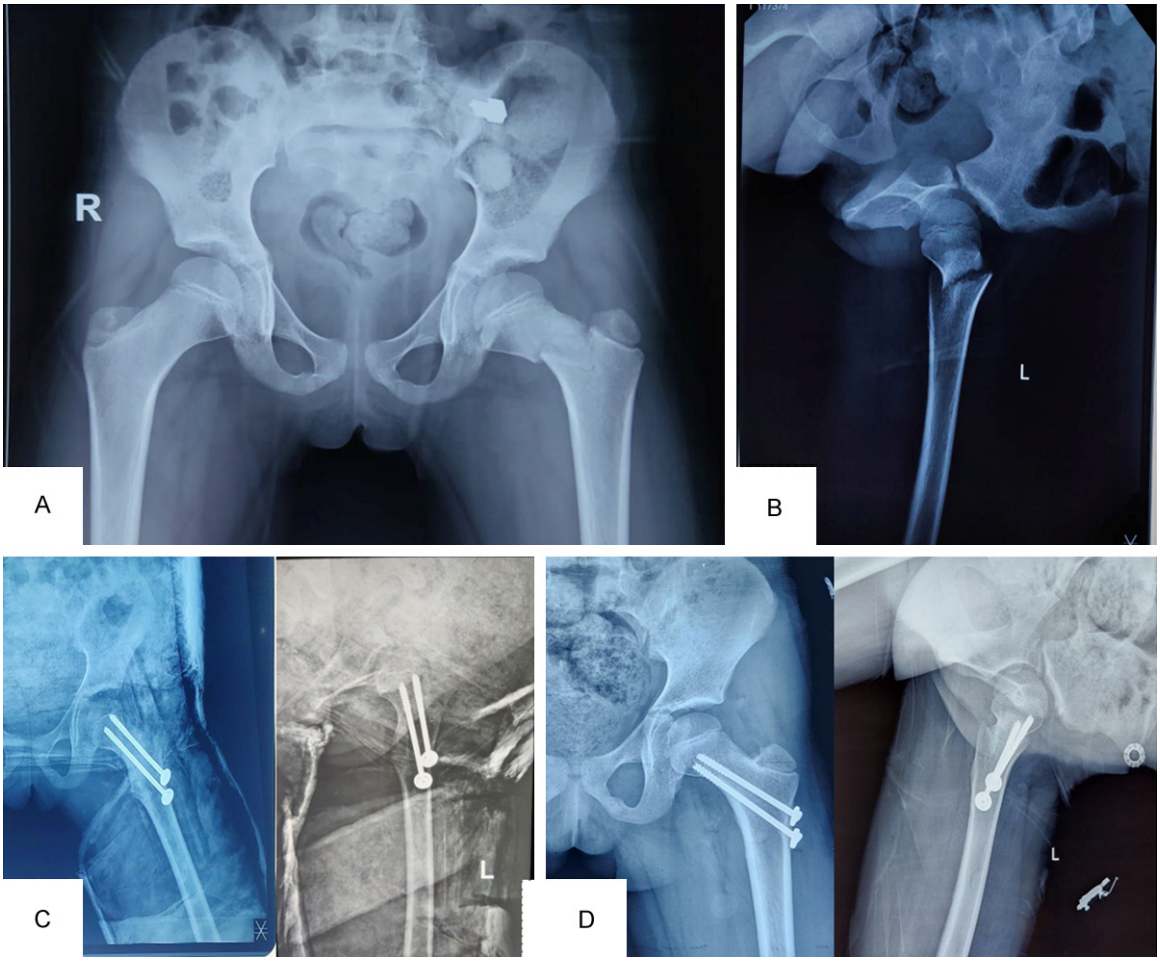

Figure 1. Case example of Delbet Type III fracture neck of femur (Group A). A, B. Pre-operative radiograph showing Delbet Type 3 left hip fracture in a 6 year old child operated 2 days after sustaining initial injury (Group A). C. Post-operative radiograph showing good reduction and alignment after fixation with 2 CCS. D. Plain radiograph at 14 months follow-up showing uncomplicated union.

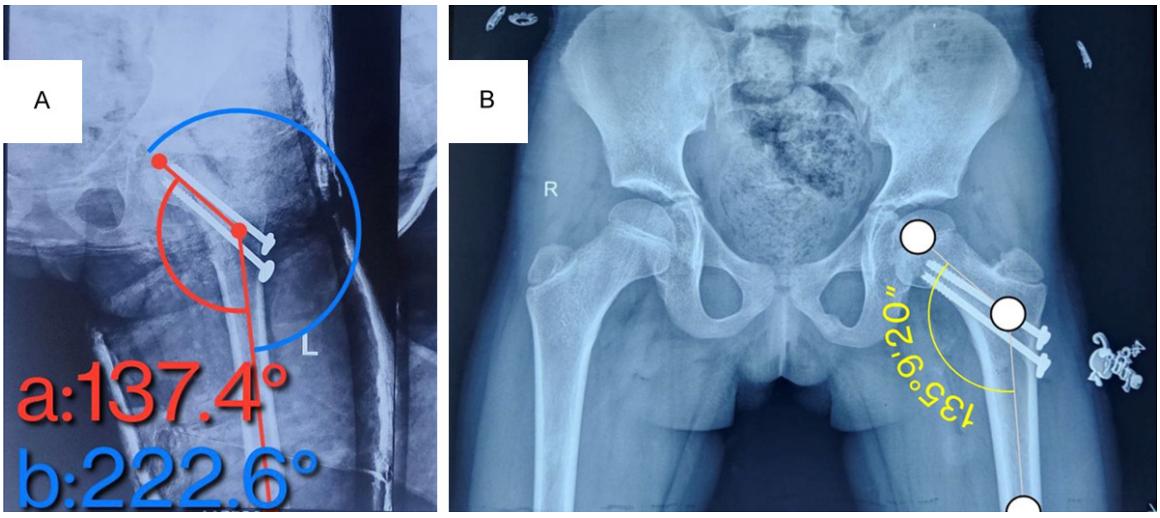

Figure 2. Ratliff scoring of the of Delbet Type III fracture neck of femur (Group A). A. Immediate post-operative radiograph of the patient showing NSA of 137.4 degrees. B. Final follow-up radiograph showing NSA of 135.9 degrees. Secondary loss of reduction in NSA is 1.5 degrees (clinically insignificant). Patient was classified as having a "good" outcome according to Ratliff system.

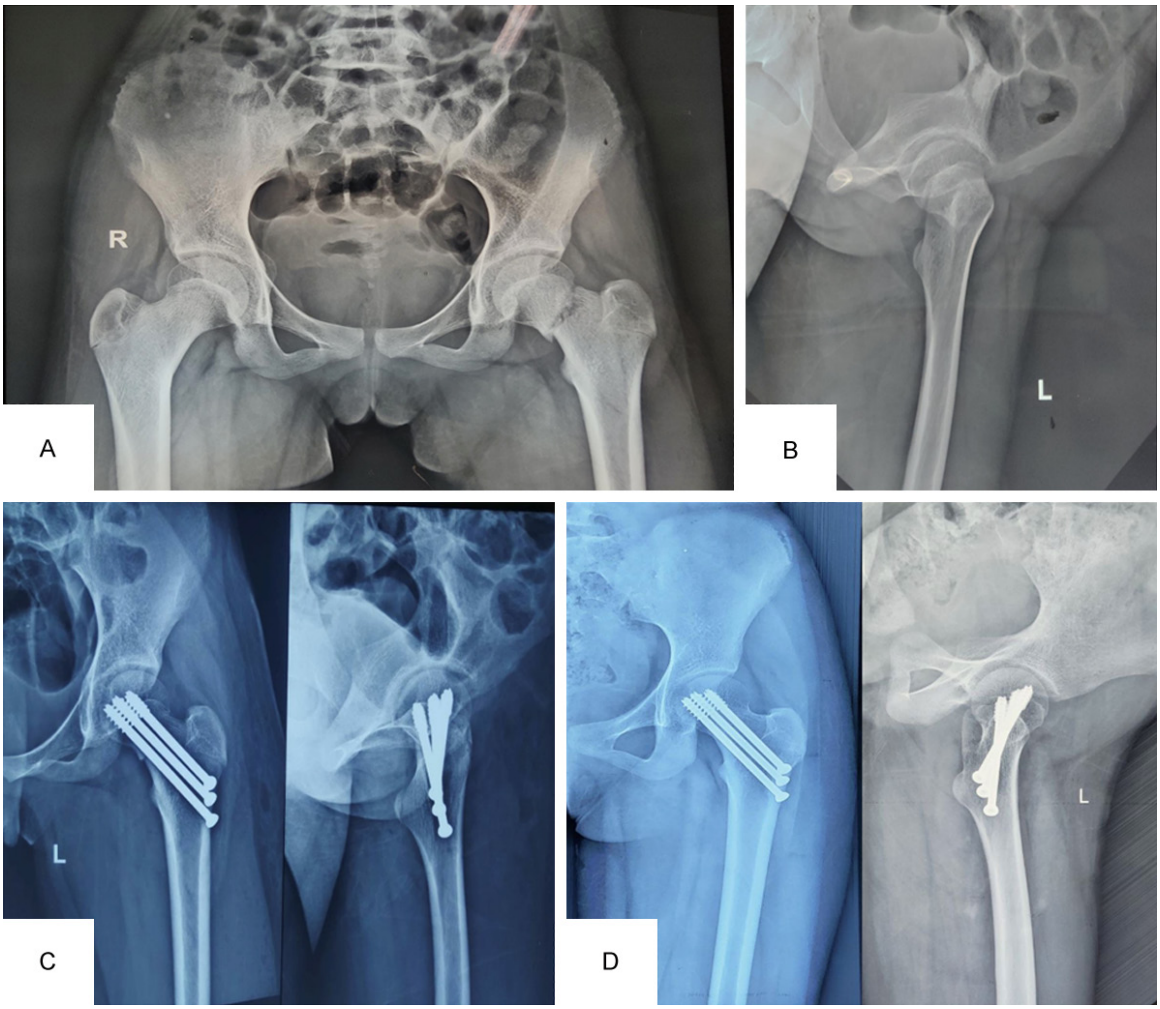

Figure 3. Case example of Delbet Type II fracture neck of femur (Group A). A, B. Pre-operative radiographs showing Delbet Type II left hip fracture in a 13 year old female child operated 3 days after the initial injury (Group A). C. Post-operative radiograph showing excellent reduction and alignment after fixation with 3 CCS. D. Plain radiograph at 18 months follow-up showing good union.

determined using the following scale by careful analyses of post-operative radiographs.

Excellent = less than 2 mm step off and no angulation.

Good = less than 4 mm step off and less than 5° angulation.

Fair = greater than 4 mm step off and less than 10° of angulation.

Poor = greater than 5 mm step off and greater than 10° of angulation.

Excellent and good quality reductions were considered "anatomical" reductions while fair and poor quality reductions were considered "unacceptable".

Secondary loss of reduction

In each patient, the neck shaft angle (NSA) was measured on the immediate post-operative x-rays and at union to determine the secondary loss of reduction. A change in NSA of ≥ 5 degrees was considered a significant loss of reduction. Stable anatomical fixation decreases the secondary loss of reduction. NSA of < 120 degrees in the final follow-up X-ray was considered as coxa vara.

Post-operative protocol & outcome evaluation

In the 24 to 48-hour post-operative interval, injectable antibiotics were continued. For all children under the age of eight, spica cast immobilization was used because of the incon-

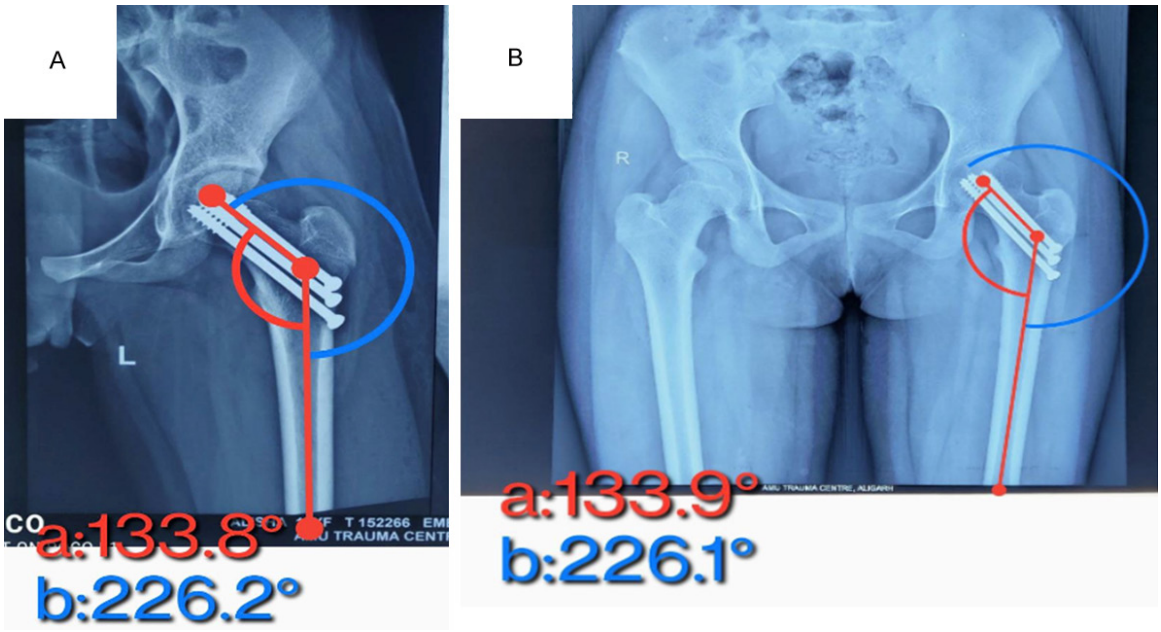

Figure 4. Ratliff scoring of the of Delbet Type II fracture neck of femur (Group A). A. Immediate post-operative radiograph of the same patient showing NSA of 133.8 degrees. B. Final follow-up radiograph showing NSA of 133.9 degrees. The secondary loss of reduction in NSA is 0.1 degree and overall patient was classified as having a "good" outcome according to Ratliff system.

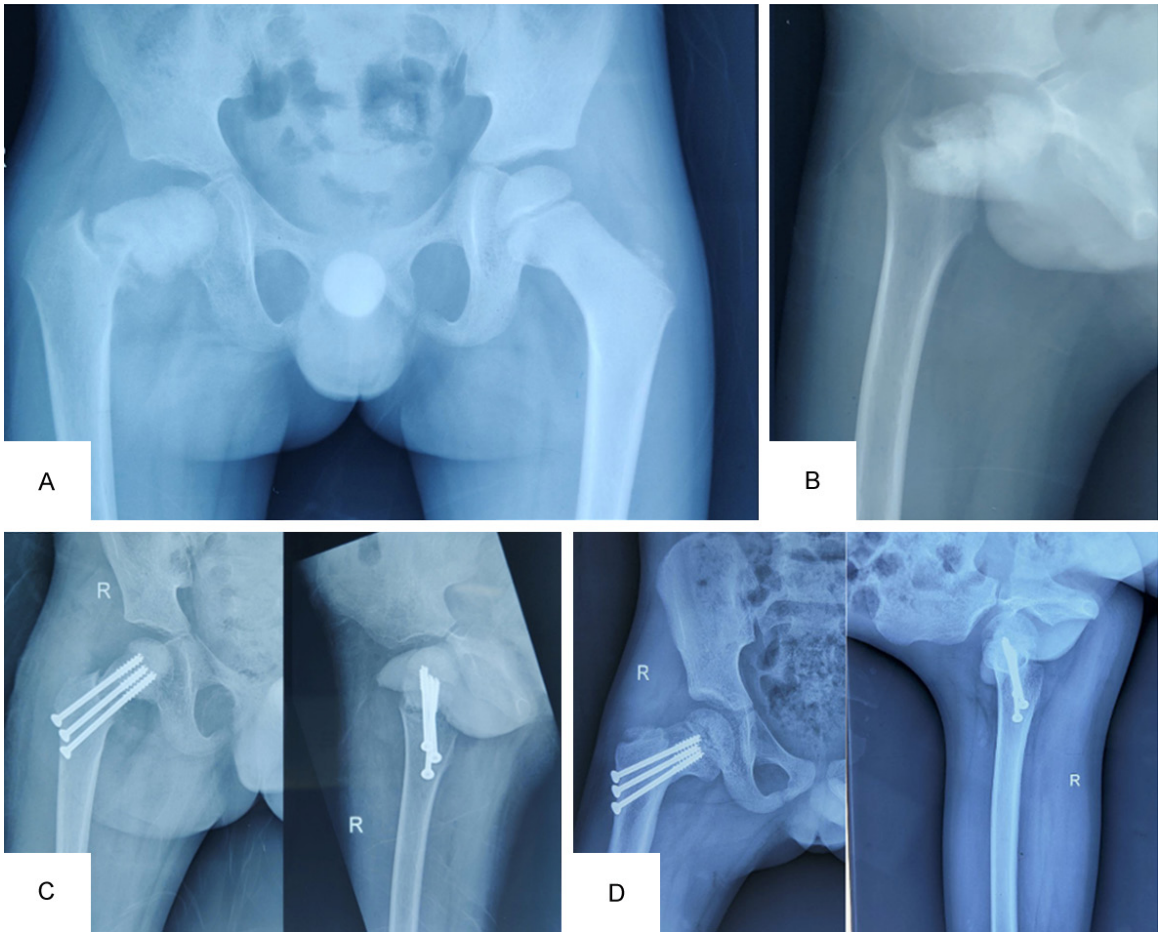

Figure 5. Case example of Delbet Type III fracture neck of femur (Group B). A, B. Pre-operative radiograph showing Delbet Type III right hip fracture in a 5 year old male child operated 20 days after the initial injury (Group B). C. Post-operative radiograph showing "fair" quality of reduction & alignment after fixation with 3 CCS. D. Radiograph at 18 months follow-up showing union with development of coxa vara.

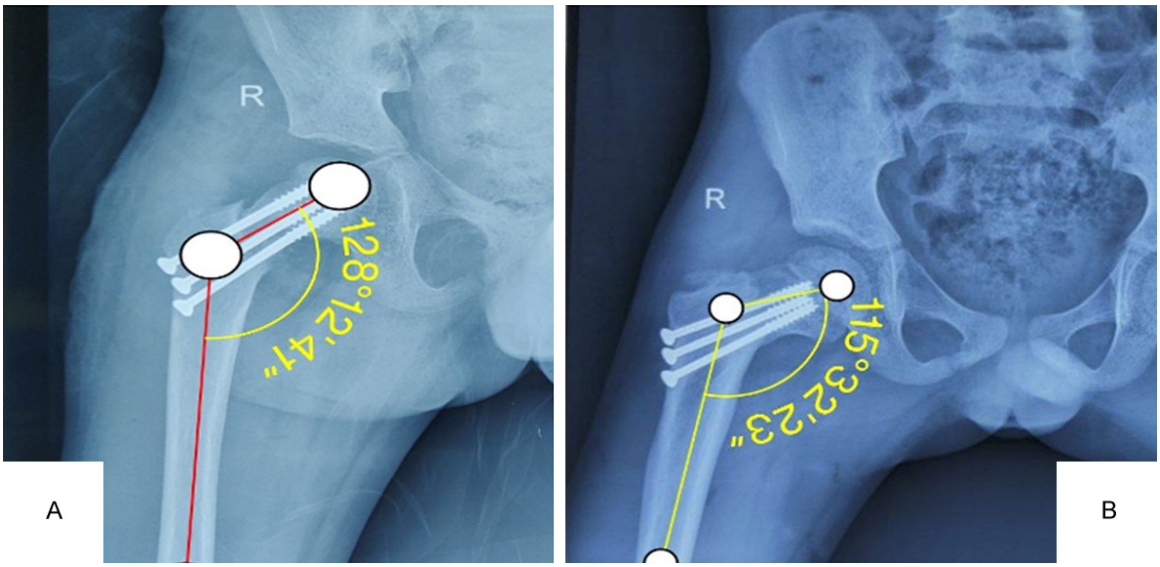

Figure 6. Ratliff scoring of the of Delbet Type III fracture neck of femur (Group B). A. Immediate post-operative radiograph of same patient showing NSA of 128.1 degrees. B. Final follow-up radiograph showing NSA of 115.3 degrees (Coxa Vara). The secondary loss of reduction in NSA is 12.8 degrees and overall patient was classified as having a "fair" outcome according to Ratliff system.

sistency of family monitoring and the child's compliance. Children who had stable fracture reduction and transphyseal fixation did not need to be immobilized in a spica cast and were allowed to walk on crutches on the first post-operative day. Immobilization in a spica cast was continued for 6 to 8 weeks. Stitch removal was done after a period of 12-14 days. On radiological fracture union, patients were allowed to bear full weight. The patients were followed up every 4 weekly for the first 6 months, then 8 weekly for the next 6 months, followed by 3 monthly intervals with relevant X-rays to assess the fracture union and complications. Complications like avascular necrosis by Ratliff's classification, non-union, coxa vara, and premature physeal closure were assessed. Assessment of the final outcome by Ratliff's method was done at the last follow-up (**Table 1**).

Statistical analysis

Numbers and percentages were used to present the categorical variables. On the other hand, quantitative data were displayed as means with standard deviations and ranges. For instances where the data was not normal, non-parametric tests were used. The results were subjected to subsequent statistical tests 1. To compare normally distributed data between two groups, an independent t-test was performed. 2. Fisher's exact test was used to compare the qualitative variables because at least one cell had an expected value that was less than 5. The Statistical Package for Social Sciences (SPSS), version 21.0, from IBM (Chicago, USA), was used to conduct the final analysis. A p value of less than 0.05 was considered statistically significant.

Results

Study population and demographic characteristics

In total, 15 paediatric femoral neck fracture patients were included in the study, 11 of whom underwent surgery within 7 days (group A), and 4 patients were operated after 7 days (group B) with the purpose of comparing the rate of fracture union and incidence of complications in

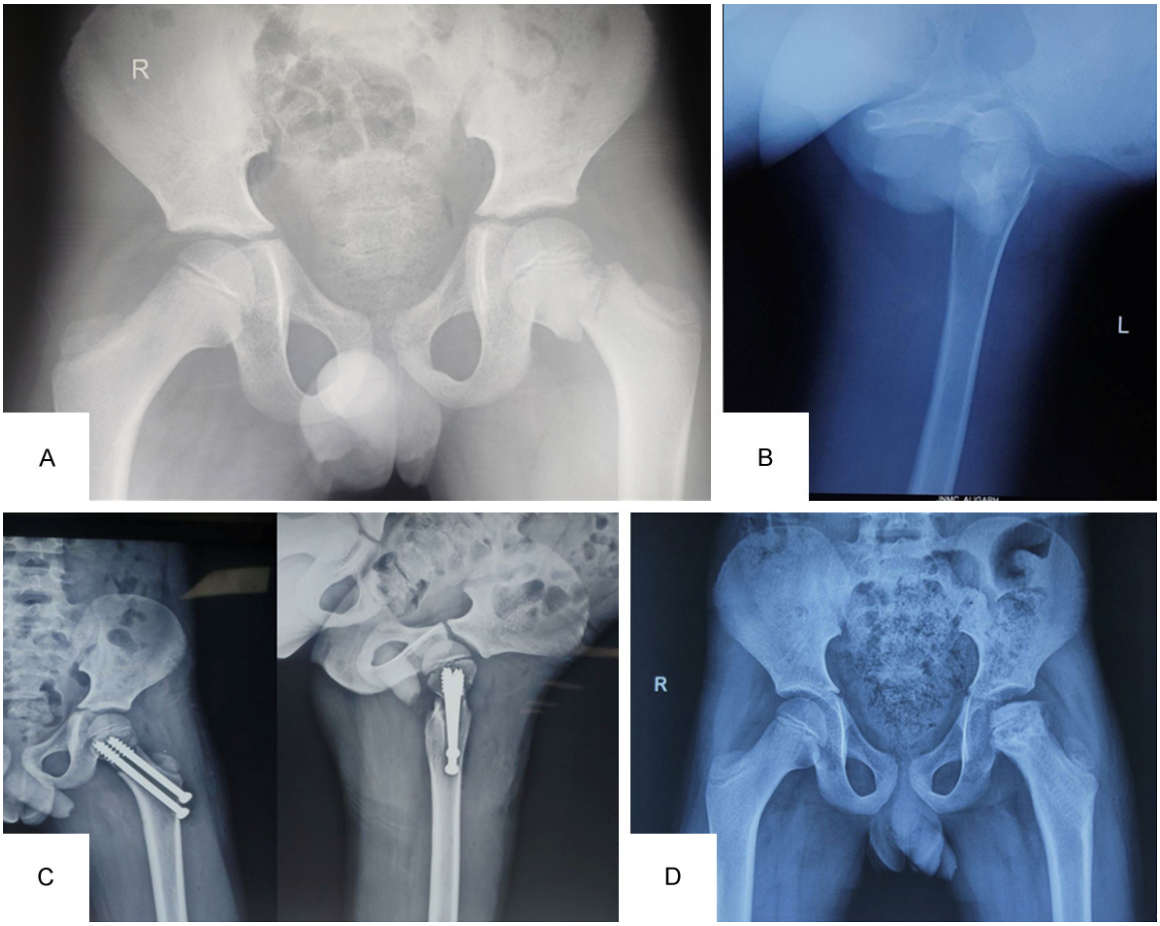

Figure 7. Case example of Delbet Type II fracture neck of femur (Group B) showing development of avascular necrosis of femoral head. A, B. Pre-operative radiograph showing Delbet Type II fracture of left hip in a 10 year old child operated 14 days after the initial injury (Group B). C. Post-operative radiograph showing poor quality of reduction and fixation of fracture with 2 CCS. D. Plain radiograph at 8 months follow-up after implant removal showing flattening and collapse of femoral head indicative of avascular necrosis of left femoral head. The patient had complaints of a painful limp along with restricted movements of the left hip joint. Patient was classified as having a "poor" outcome according to Ratliff system.

both the groups. The distribution of age, sex, mechanism of injury, and fracture pattern was not significantly different between the two groups according to pre-operative data (**Table 2**). In group A, the mean age of patients was 10.1 ± 3.65 years, ranging from 3 to 15 years, and in group B the mean age of patients was 8.5 ± 3.2 years, ranging from 5 to 13 years. Male patients outnumbered female patients in both groups (54.55% males in group A and 75% males in group B). The most frequent cause of injury in both groups was falling from a height.

Distribution of Delbet fracture type and operative details

It was found that Delbet type II fracture pattern (54.54%) was more common than type III in group A (≤ 7 days), while the incidence of type III and type II fracture patterns was equally distributed (50%) in group B (> 7 days). The mean operation time (**Table 3**) in group A was 55 ± 8.25 minutes, ranging from 45 to 70 minutes, while in group B was 65 ± 15 minutes which ranged from 50 to 90 minutes which was not statistically significant (p-value > 0.05). Paediatric DHS and CCS were used for fracture fixation in our study. In group A, 90.9% of patients underwent CCS fixation, while in group B, 75% of patients underwent fixation by CCS. The quality of reduction in post-operative radiographs was anatomical in 10 (90.9%) patients and unacceptable in 1 (9.1%) patient. While in group B, 2 (50%) patients had an anatomical reduction while 2 (50%) patients had an unacceptable reduction. In all patients, the reduc-

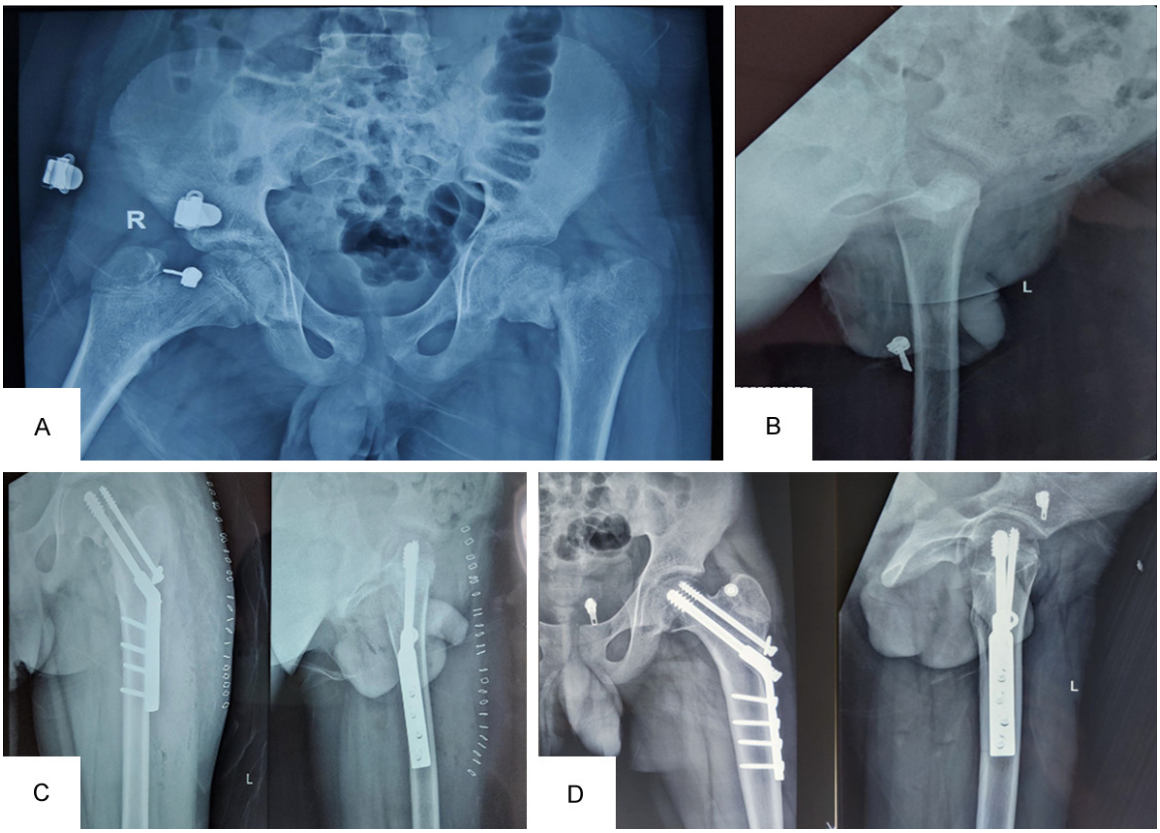

Figure 8. Case example of Delbet Type III fracture neck of femur (Group B) showing premature physeal closure. A, B. Pre-operative radiograph showing Delbet Type III fracture of left hip in a 11 year old male child operated 12 days after the initial injury (Group B). C. Post-operative radiograph showing good quality of reduction & fracture fixation with paediatric DHS. D. Plain radiograph at 12 months follow-up showing union with premature physeal closure. The patient also had a limb length discrepancy of 1.5 cm with "good" outcome according to Ratliff system.

tion was done by a closed method, and none underwent open reduction.

Ratliff scoring

According to Ratliff scoring [3], in Group A (≤ 7 days), 10 (90.9%) patients had a satisfactory outcome, and only 1 (9.1%) patient had an unsatisfactory outcome, while in Group B (> 7 days), 3 (75%) patients had an unsatisfactory outcome while only 1 (25%) patient had a satisfactory outcome. The *p*-value was 0.033 using Fisher's exact test, which is statistically significant.

Follow-up, fracture union and complications

Fracture union was seen in all our patients in both groups, and none underwent non-union. The mean union time was 11.11 ± 7.06 weeks in group A and 16.5 ± 2.59 weeks in group B. The *p*-value was 0.0189, which was statistically significant. So, the union was delayed in patients who were operated after 7 days (**Table 4**). Out of 11 patients in group A, only 1 (9.1%) patient developed coxa vara, which had a fair (unacceptable) reduction. In group B, out of 4 patients, 3 (75%) patients developed complications. One patient (25%) developed avascular necrosis of the femoral head and had a poor (unacceptable) quality of reduction, 1 (25%) patient developed coxa vara and 1 (25%) patient developed premature physeal closure and limb length variation.

Discussion

In the paediatric population, femur neck fractures are exceptionally rare [1, 4, 11] as the child's bones are quite resilient, necessitating a high-energy trauma [12]. Our data supports the etiological factors because the fractures were caused by high-energy trauma in almost all cases, the most common cause being fall

Table 1. Ratliff's clinical and radiological assessment system [3]

	Good	Fair	Poor
Pain	No or Negligible Pain	Occasional pain	Disabling pain
Range of motion	Full or minimal restriction	Restriction less than 50%	Restriction more than 50%
Activity	Normal or patient avoid games	Normal or patient avoid games	Restricted activity
Roentgenogram	Normal or minimal deformity	Severe deformity and mild avascular necrosis	Severe avascular necrosis, degenerative arthritis or arthrodesis

Table 2. Pre-operative patient characteristics between Group A (Operated ≤ 7 days) and Group B (Operated > 7 days)

Patient variable	Operated ≤ 7 days (Group A)	Operated > 7 days (Group B)	*p*-value
Age			
Average (years)	10.1 ± 3.65	8.5 ± 3.2	0.243*
Range (years)	3-15	5-13	
Sex			
Female	5 (45.45%)	1 (25%)	0.604‡
Male	6 (54.55%)	3 (75%)	
Mode of injury			
FFH	7 (63.64%)	3 (75%)	0.653‡
RTA	2 (18.18%)	1 (25%)	
Others	2 (18.18%)	-	
Delbet classification			
Type I	1 (9.09%)	-	0.754‡
Type II	6 (54.54%)	2 (50%)	
Type III	3 (27.28%)	2 (50%)	
Type IV	1 (9.09%)	-	
Implants Used			
CCS	10 (90.9%)	3 (75%)	0.476‡
Paediatric DHS	1 (9.1%)	1 (25%)	

*Independent t test, ‡Fisher's exact test.

Table 3. Intra-operative assessment between Group A (Operated ≤ 7 days) and Group B (Operated > 7 days)

Variable	Operated ≤ 7 days (Group A)	Operated > 7 days (Group B)	*p*-value
Duration of operation (minutes)			
Average	55 ± 8.25	65 ± 15	0.076*
Range	45-70	50-90	
Quality Of Reduction			
Excellent	3 (27.27%)	-	0.213‡
Good	7 (63.63%)	2 (50%)	
Fair	1 (9.09%)	1 (25%)	
Poor	-	1 (25%)	

*Independent t test, ‡Fisher's exact test.

from height. According to the Delbet and Colonna categorization system, femoral neck fractures are divided into different categories [12, 13]. Delbet type II fractures, followed by type III fractures, were the most prevalent according to the majority of studies on fracture

Table 4. Post-operative assessment & complications in group A (Operated ≤ 7 days) & group B (Operated > 7 days)

Parameters	Operated ≤ 7 days (Group A)	Operated > 7 days (Group B)	*p*-value
Duration of follow-up (months)			
Average	9.18 ± 6.40	15.25 ± 6.05	0.074*
Range	3-23	7-24	
Union time (weeks)			
Average	11.11 ± 7.06	16.5 ± 2.59	*0.0189**
Change in neck shaft angle (NSA)			
≤ 5 Degrees	9	2	0.516‡
> 5 Degrees	2	2	
Complications			
Coxa vara	1 (9.1%)	1 (25%)	
AVN	-	1 (25%)	
Premature physeal closure & limb length discrepancy	-	1 (25%)	
Total	1 (9.1%)	3 (75%)	0.033‡
Relation between choice of implant & occurrence of complications	Complications	No complications	
Cannulated Cancellous Screw	3	10	0.476‡
Paediatric D.H.S.	1	1	

*Independent t test, ‡Fisher's exact test.

of the neck of the femur in children [1, 11, 14], as was observed in our study, type II being the most common subtype in 8 (53.33%) patients followed by type III in 5 (33.33%) patients. According to certain studies [14], children who underwent open reduction and internal fixation (ORIF) for type II and type III fractures experienced fewer complications than those who underwent closed reduction and internal fixation (CRIF). We avoided performing an open reduction in our study because of the potential interruption of the unique blood supply to the paediatric femoral neck, which may raise the chances of avascular necrosis of the femoral head. However, more recent research indicates that individuals receiving ORIF treatment have a lower incidence of avascular necrosis [15]. The main factors causing complications in paediatric femoral neck fractures are controversial. Literature supports that early fracture reduction and stabilization lowers the risk of complications [3, 16], as observed in our study.

The primary objective of the present study was to compare the incidence of complications and union rates in children presenting early (≤ 7 days) following injury with children presenting later (> 7 days). Functional and radiological outcome according to the Ratliff System, were also compared along with union time between the two groups. By specifying the inclusion criteria carefully, we were able to create a more homogeneous group.

Functional outcome

According to the Ratliff System, the final functional and radiological outcome was evaluated [3]. The satisfactory group was graded as "satisfactory" outcome according to Ratliff's assessment and had no complications. The unsatisfactory group was graded as "fair" or "poor" or who had complications [15]. Ten patients (90.1%) in group A had a satisfactory outcome, and only 1 (9.1%) patient developed coxa vara that had an unsatisfactory outcome. One patient (25%) in group B had a satisfactory outcome and 3 (75%) patients had an unsatisfactory outcome, out of which 2 had fair and 1 had a poor outcome due to avascular necrosis of the femoral head. There was a statistically significant difference in the final functional outcome between group A (≤ 7 days) and group B (> 7 days) with *p*-value < 0.05 by Fischer's Exact Test (**Table 5**). Overall 73.33% of our patients had a satisfactory outcome which is comparable to previous studies done by Song [15] (78%), Bali [14] (75%), Pavone [17] (75%), Cici and Kiliç [18] (83.3%) representing that early stable surgical fixation of paediatric femo-

Table 5. Outcome by Ratliff system of clinical and radiographic assessment in group A (Operated ≤ 7 days) & group B (Operated > 7 days) patients at final follow-up

Outcome	Operated ≤ 7 days (Group A)	Operated > 7 days (Group B)	*p*-value
Satisfactory outcome	10 (90.9%)	1 (25%)	0.033‡
Unsatisfactory outcome	1 (9.1%)	3 (75%)	

‡Fisher's exact test.

ral neck fractures with good anatomical reduction yields satisfactory outcomes.

Radiological outcome

Fracture union was seen in all our patients in both groups A and B. Mean time to union in group A was 11.11 ± 7.06 weeks, and in group B, it was 16.5 ± 2.59 weeks, which is similar to the study done by Singh [19] in which they found a union time of 12.37 ± 7.06 weeks in the early treatment group and 19.00 ± 17.03 weeks in the delayed treatment group. This inconsistency in healing time is due to differences in the timing of treatment from injury to surgery, which affects the healing rate. Other studies by Shrader [16], Varshney [20], and Panigrahi [21] also found a union time in the range of 12-16 weeks which is comparable to our study.

Secondary loss of reduction

In group A, the change in neck-shaft angle was < 5 degrees in 9 (81.81%) patients and ≥ 5 degrees in 2 (18.19%) patients, out of which one developed coxa vara. In group B, the change in neck-shaft angle was < 5 degrees in 2 (50%) patients and ≥ 5 degrees in 2 (50%) patients, out of which one patient developed coxa vara. One independent risk factor for coxa vara that has been established is reduction quality, which may be somewhat managed by the surgeon, as opposed to fracture displacement or Delbet type. In the literature [11, 22], it was found that operative treatment for femoral neck fractures with internal fixation and good reduction quality was associated with a decreased incidence of coxa vara. In our study, both patients who developed coxa vara had a "fair" quality of reduction, which may be attributed to the cause of coxa vara. In the delayed treatment group, getting an excellent or good anatomical reduction by closed methods is difficult. Open reduction was not attempted in younger children because of controversial opinions in various literature.

Choice of implant and occurrence of complications

The operating surgeon's preferences, the age of the child sustaining the fracture, the size of the femur, and skeletal maturity all play a role in the selection of implants. According to Canale [4], utilizing fewer pins appears to lower the occurrence of complications, as this arrangement would prevent the diameter of the femoral neck from being completely filled, which would otherwise impede the precarious femoral head blood supply. The literature does not provide evidence that the frequency of post-operative problems like avascular necrosis or coxa vara is influenced by the type of implant used [23, 24]. We also found in the study that there was no discernible difference between the rates of post-operative complications for CCS and paediatric DHS, with *p*-value being 0.476 (**Table 4**). Our results confirm that most young toddlers can tolerate internal fixation with two CCS, and for older children 3 CCS or paediatric DHS both can be used depending upon the diameter of the femoral neck or fracture geometry (Delbet subtype).

Complications

Femoral neck fractures can result in numerous complications, AVN being the most significant. The reported range for the prevalence of AVN in children following femur neck fractures is 0 to 92% [25]. According to Flynn [26], of the 18 patients who had undergone closed reduction and internal fixation within 24 hours, 15 had no complications; one suffered AVN, one suffered non-union, and one developed an early epiphyseal closure. Numerous additional studies have also shown that internal fixation can significantly lower AVN incidence when carried out within 24 hours of the injury [27-29]. In our study, the rate of AVN was 6.7%, which was observed in the delayed treatment group B. In the early treatment group, no patients experienced AVN. In addition to AVN, coxa vara occurs often in children with femoral neck fractures, with a

20-30% incidence rate [30]. In our study, a total of 2 (13.33%) patients developed coxa vara, one each in groups A and B. The level of reduction attained during surgery has an impact on how coxa vara develops. Both the patients had a fair quality of reduction, predisposing to secondary loss of reduction at healing (union). The fact that all of our patients underwent internal fixation may have contributed to the low overall incidence of coxa vara. When compared between group A (≤ 7 days) and group B (> 7 days), the incidence of complications was higher in group B with a *p*-value of 0.033, making it statistically significant. According to the study by Shrader [16], there was no relationship between early fixation and the development of complications like AVN. Azam [31] concluded that complications were more common when surgery was put off for more than 48 hours compared to a recent series of studies where the fracture was treated within 24 hours. Varshney [20] found that osteonecrosis is primarily linked to delayed treatment. They also found that fracture type, age and sex are insignificant and have no relationship to the occurrence of complications. Bukva [3], in their study of 28 patients, found a decrease in the incidence of AVN with early treatment. Singh [19] concluded that complications are equally common in both early and late-presented groups of children with neck femur fractures, with the exception of the time to union. In our study, we observed an increase in the incidence of complications with delay in treatment which is statistically significant. The union time was also higher in patients who were in the delayed treatment group probably due to more healing time. No significant difference was seen between the type of implant and the occurrence of complications.

Strengths, limitations, and future recommendations

Our study makes a comparison between the rate of union and frequency of complications in children presenting early (≤ 7 days) following injury with children presenting later (> 7 days). Functional and radiological outcomes, according to the Ratliff System, were also compared along with union time between the two groups. The strengths of the study are the inclusion of all Delbet fracture types and definite treatment protocol with standard evaluating tools. However, the small sample size and the short follow-up are the limitations of the current study. Therefore, a further study comparing the two groups with improved age group stratification, equal distribution of sex ratios, and extensive follow-up is necessary for better conclusions regarding the importance of early stable reduction for preventing complications like avascular necrosis, which has a poor outcome.

Conclusion

The distinctive anatomical and physiological features of the paediatric bone make managing femoral neck fractures in children a challenging task. In our study, patients operated within 7 days developed fewer complications as compared to patients operated after 7 days which was statistically significant. Although AVN is a common side effect of paediatric femur neck fracture, our study demonstrated that it can be minimised with early reduction and stable fixation. Our short-term functional and radiological results using the Ratliff scoring system were comparable to previous studies owing to stable anatomic reduction. Based on our study's findings and existing literature results, we recommend early stable anatomic reduction for managing paediatric femoral neck fractures with an emphasis on long-term follow-up.

Disclosure of conflict of interest

None.

Address correspondence to: Asad Khan, Department of Orthopaedic Surgery, J.N. Medical College, Faculty of Medicine, A.M.U., Aligarh, UP, India. Tel: +91-9456086779; E-mail: khanasad53@gmail.com

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