Femoral Neck Fractures in Children: A Review

Abstract

Paediatric femoral neck fractures are uncommon injuries and are usually caused by high-energy trauma. Low-energy trauma can result in pathologic neck fractures and stress fractures of the neck, due to repetitive activity. Surgical options can vary based on age, Delbet classification and displacement of the fracture. Treatment for displaced fractures is by closed or open reduction and smooth/cancellous screw fixation. Compression screw and side plate fixation is indicated for basal fractures. Fixation should be supplemented by spica cast immobilization in younger children. The high rate of complications occurs due to the vascular anatomy of the hip and proximal femur. Avascular necrosis, coxa vara, premature physeal closure, and nonunion are the most common and these often result in poor outcome.

Keywords: *Child, fracture neck of femur, hip, pediatric, pathologic*
MeSH terms: *Pediatrics, pathology, femoral neck fractures, hip fractures*

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Introduction

Femoral neck fractures in children are uncommon injuries. It accounts for <1% of all fractures in children.[1] Most are caused by high-energy trauma due to motor vehicle accidents and fall from height. Fall from height appears to be a significant mode from the two series published from India as compared to the reports from other parts of the world.[2,3] Pathologic fractures can occur due to low-energy trauma and rarely, stress fractures due to repetitive activity like running and jumping. Despite it being a rare fracture, significant long term morbidity and complications are associated with the fracture and its treatment due to the tenuous blood supply and osseous anatomy in children. The reported rates of avascular necrosis (AVN) are variable and range from 0 to 92%,[4] and every effort to minimize this dreaded complication should be taken as the effects can be very disabling. Treatment of femoral neck fractures in the presence of an open physis in children can be challenging, and growth abnormalities, nonunion, AVN, and coxa vara can ensue as complications.

Surgical anatomy

The retinacular branches (posterosuperior and posteroinferior) of the medial circumflex artery (MCA) form the main supply to the femoral head. The lateral circumflex artery (LCA) supplies the greater trochanter, medial metaphysis, and the medial part of the physis [Figure 1]. The blood supply from the artery of the ligamantum teres and the branches of the LCA begin to regress after the age of 4 until 10 years and the postero-superior branch of the MCA becomes the major vessel supplying the head during this period. The higher risk of AVN in the growing child can be explained by the tenuous blood supply during this period.[5,6] The anterior and lateral aspects of the femoral head are predominantly supplied by the posterosuperior branch of the MCA and an anterior capsulotomy for open reduction does not jeopardize this as shown by Ganz.[7] At skeletal maturity, the retinacular vessels, artery of the ligamentum teres and the metaphyseal vessels form an anastomotic network which reduces the incidence of AVN in the young adult. The femoral neck fractures in children differ from the adults due to the tenuous nature of blood supply in children and the proximal femur with the thick periosteum being resilient, necessitating significant force to cause its breakage. Due to this mechanical property, high-energy trauma in road traffic accidents and fall from height are the two most common causes of femoral neck fracture in children.[8]

Classification

Delbet classification

Paediatric hip fractures can be divided into four types as first described by

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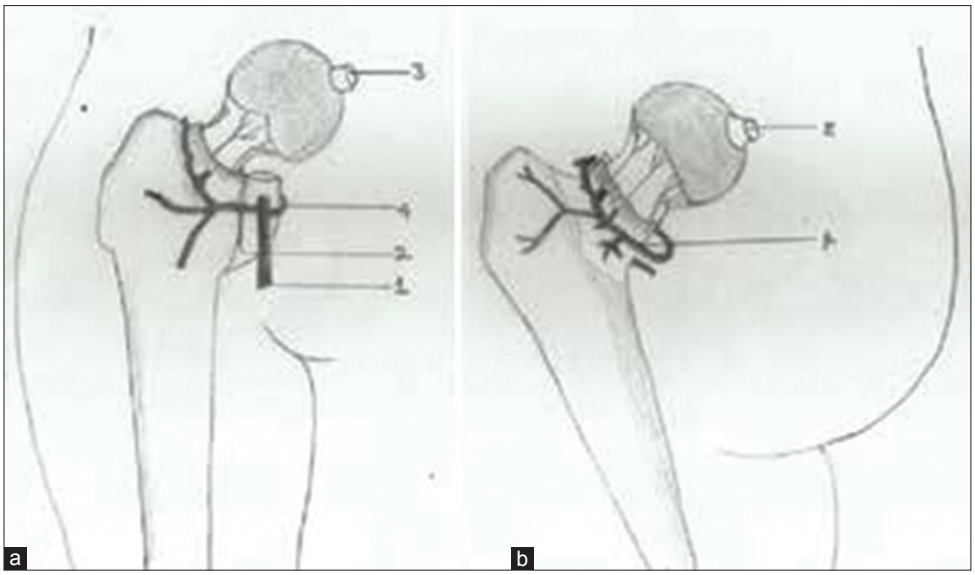

Figure 1: Schematic representation of proximal femur showing a Blood supply of the femoral head: (a) Anterior aspect-1-Femoral artery, 2-lateral circumflex artery, 3-Artery of the ligamentum teres, 4-Medial circumflex artery (b) Posterior aspect-3. Artery of the ligamentum teres 4. medial circumflex artery

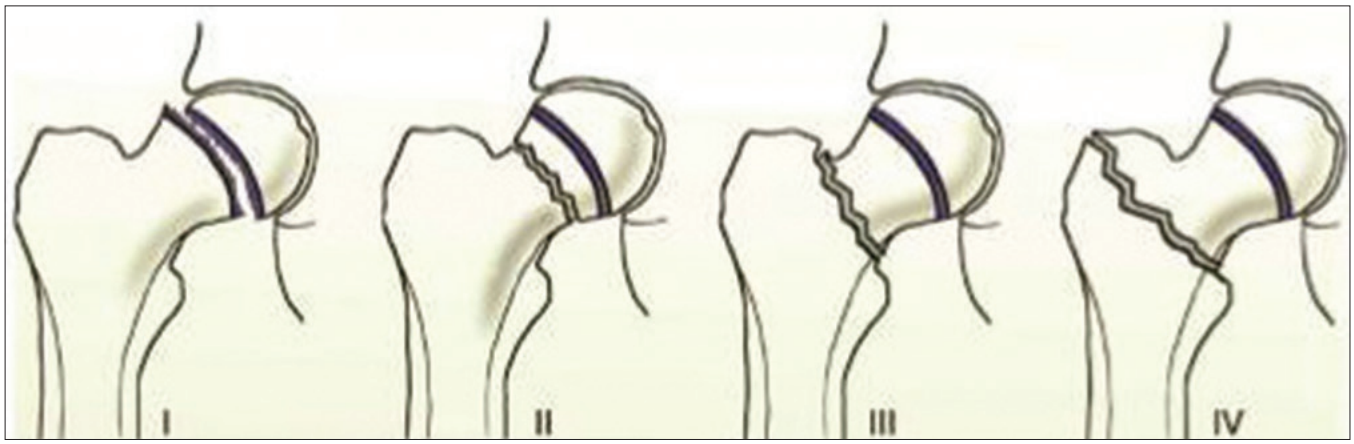

Figure 2: Schematic representation of proximal femur showing Delbet Classification (Paediatric femoral neck fractures)

Delbet [Figure 2].[9] This classification, along with other factors, helps determine operative versus nonoperative treatment and predicts the risk of AVN of the femoral head. Type I: Trans-epiphyseal separation. These are fractures through the proximal femoral physis, and represent Salter-Harris type I fractures of the proximal femur (<10%). Subtypes are IA (without dislocation) and IB (with dislocation). Type II: Transcervical fracture. This is the most common type of pediatric hip fracture (40%–50%). It extends through the mid-portion of the femoral neck. Type III: Cervicotrochanteric fracture. This fracture occurs through the base of the femoral neck (25%–35%). Type IV: Intertrochanteric fracture. This fracture between the greater and lesser trochanters accounts for 6%–15% of all pediatric hip fractures and has the best outcome. Moon and Mehlman[4] revealed that the transphyseal, transcervical, cervicotrochanteric were 15, 6, 4 times as likely, respectively, to develop AVN as the intertrochanteric type.

Diagnosis

The child is fearful of any passive movement and unable to move actively. Nerve blocks for initial pain relief in pediatric femoral fractures in the form of femoral nerve blocks and fascia iliaca compartment block have been described.[10] The diagnosis is confirmed by plain radiographs in two planes. The anteroposterior (AP) view of the pelvis with the hip extended and 15 degrees internally rotated, as tolerated by the patient, will serve to compare any displacement with the opposite side. Cross table lateral view to avoid any displacement and pain while mobilization should also be taken and a full-length radiograph AP and lateral views of the femur are also taken to complete the assessment. An experienced ultrasonologist can detect a fracture line and fracture hematoma in doubtful cases. A recent study concluded that it does not appear that routine computed tomography scanning to evaluate

concomitant femoral neck fractures in association with ipsilateral femoral shaft fractures as in adults is justifiable due to the risks of radiation exposure in the young and the low incidence of such injuries in children (<0.7%).[11] Magnetic resonance imaging (MRI) can be taken in special situations to detect a stress fracture.[12]

Special situations

Stress fractures

Stress fractures of the femoral neck can be challenging to diagnose in children both for its rarity and the broadly associated differential diagnosis which may include muscle strain, transient synovitis, Perthe's disease, dysplasia, infection, malignancy, and fracture.[13] The findings may be subtle, and it is difficult to diagnose on plain radiography alone and often requires an MRI to detect occult lesions which generate bone edema. Specifically, in patients with the female athelete triad (eating disorder, amenorrhea, and decreased bone mineral density), a thorough workup should be done to avoid missing this injury.[12]

Pathologic fractures

A fracture caused by relatively minor trauma and low energy could be indicative of a pathologic condition such as a cyst, disuse osteopenia[14] or rarely, an inherited neuro-cutaneous disease such as Sjogren Larsson syndrome.[15] It is not an uncommon problem faced by the pediatric orthopedic surgeon and these fractures are at significant risk for complications and prolonged time for union.

Child abuse

Femoral neck fractures have been reported as an atypical presentation of child abuse.[16,17] It is difficult to distinguish child abuse from other accidental injury and in fact, it has been proposed that one-third of femur fractures under the age of 4 and 80% of femur fractures in children who are not yet walking have an abusive etiology.

Management

The principles of management include minimizing potential complication of AVN, avoiding injury to growth plate if

Figure 3: X-ray of left hip joint anteroposterior view showing (a) Transcervical fracture delbet type II (b) Multiple cancellous screw fixation for Delbet type II

Table 1: List of a recent studies on fracture neck of femur in children

Study	Type of study	Number of patients enrolled	Mean age of patients	Follow up duration	Salient features
Bukva *et al*., 2015[8]	Research study	28	10.75	9 years	Positive effect of urgent treatment within 12-h interval after injury
Ju *et al*., 2016[22]	Research study	58	9.1	3 years	Open reduction and internal fixation yielded better outcomes than closed reduction and internal fixation
Bali *et al*., 2011[2]	Research study	36	10	1 year	Internal fixation preferable to conservative treatment which carries high risk of failure of reduction

possible, anatomical reduction of fragments, and stabilization with pins or screws allowing early protected weight-bearing.[18]

Closed reduction and percutaneous pinning

Closed reduction and percutaneous pinning can be carried out in certain situations. In very young infants and toddlers under the age of 2 and unstable neck fractures type II or III, closed reduction and fixation with smooth 1.8 or 2 mm K wires may be carried out. Older children above ages 4–6 years with type I physeal separation and unstable type II or III fracture, cannulated screw fixation using 4–4.5 mm cannulated screws may be carried out [Figure 3]. C-arm fluoroscopy can be brought in from the contralateral side and reduction can be attempted for displaced fractures of the above-mentioned types with traction, abduction, and internal rotation. If, reduction is not anatomic, surgeon can change plans and proceed to open reduction using either the Smith-Peterson (anterior approach) or the Watson-Jones (antero-lateral approach) based on surgeon preference.[19] Two or three K wires provide enough stability and should be placed across the physis in a parallel fashion. In young children, two screws provide enough stability, but in older adolescents, three screws may be required.

Figure 4: X-ray right hip joint anteroposterior view showing (a) Cervico-trochanteric fracture Delbet type III (b) Dynamic hip screw fixation for Delbet type III

Figure 5: X-ray of left hip joint anteroposterior views showing (a) Nonunion neck of femur, Delbet type III, Pauwels 3, in a 14-year-old boy. (b) Immediate postoperative after valgus osteotomy with blade plate. (c) Union with no evidence of avascular necrosis 1 year after surgery

Open reduction

Open reduction is indicated for fractures which cannot be anatomically reduced by gentle manipulation. This should be carried out without any delay (<24 h) since this potentially can reduce the incidence of AVN.[20]

Plate fixation

Delbet type III and IV fractures can be fixed by plates. The standard dynamic hip screw constructs which are sized for children, adolescents, and adults can be used [Figure 4]. There are also newer generation locking plates which allow locking screws to be placed into the femoral neck. These come in sizes of small (3.5 mm) or large (5 mm) with varying degrees of screw plate angle.

Minimally invasive surgery has a place in undisplaced fractures, and cannulated screws can be inserted directly on guide wires to achieve firm and compressive fixation of the fragments. Threads can cross the physis from the age of 15 onward without the risk of major limb length discrepancy from premature growth arrest. The use of small diameter smooth pins e.g., Moore's pins, in such instances can lead to inadequate fixation and distraction of fragments.[21]

In a recent study of 58 children with displaced femoral neck fractures, open reduction with internal fixation was compared with closed reduction and internal fixation and the results of open reduction were superior with a lower incidence of AVN and better outcomes than the closed reduction internal fixation group.[22]

Decompression of the hip joint after femoral neck fracture remains controversial with some studies supporting it while other studies have failed to find it beneficial[19] [Table 1].

Postoperative management

In younger children <7–8 years and in Delbet types I, II and III with the risk of displacement after fixation, a single hip spica should be applied. In older patients with type III, IV fractures, stable fixation with plates as mentioned above, can be carried out for earlier mobilization. Hip spica immobilization may be needed in children with inadequate fixation, unreliable patients, and in patients with poor bone biology.

Complications

Avascular necrosis

It is the most common and serious complication after femoral neck fractures. Literature reveals a high incidence of AVN in transepiphyseal separations (Delbet type I), especially if the fracture is displaced or associated with hip dislocation.[23,24] Most authors agree that AVN is related to the amount of initial displacement leading to disruption or kinking of the tenuous blood supply described earlier. One author feels age more than 10 years and delay in fracture treatment can be a risk factor for AVN.[4] Pain and limitation of range of movement are the first signs of AVN and Ogden.[25] recommends a bone scan at 3 months and 12 months post injury for its detection. Ratliff has described three type of AVN after fracture.[26] Type I has the worst prognosis and involves the entire head. Type II involves only a portion of the head and in type III, there is a zone of AVN from the fracture line until the physis. Remodeling of the femoral head may occur, especially in the younger child, and it can take up to 5 years.[27] Bukva *et al*., in their study of 28 patients, with a mean age of 10.75 years and average followup of 9 years unequivocally suggested a 12-hour interval for initiation of treatment after injury, as optimal time limit, to decrease the incidence of AVN.[8] Maeda *et al*. proposed a non-weight bearing regime for more than 1 year to avoid severe collapse.[28] Many joint preserving surgeries including core decompression, vascularized, and non-vascularized bone grafting has been described but no single procedure has produced reproducible or satisfactory long term results.[19] It may be necessary to perform a rotational osteotomy or a total hip replacement if such interventions are unsuccessful.

Nonunion

Nonunion can occur in 6%–10% of all paediatric hip fractures.[29] Failure to obtain, or maintain anatomical reduction can result in nonunion. Nonunion, unlike AVN, has to be treated operatively and a valgus osteotomy is sufficient to obtain secondary union [Figure 5]. Fibular strut grafts have been described for treatment of nonunion of femoral neck fractures in children.[30]

Premature physeal closure

A significant correlation between AVN and premature physeal closure has been reported by some authors.[26,31] The incidence was more when the physis was penetrated by an internal fixation device, but Hughes and Beaty[27] have stressed that stable fixation should be given priority over preservation of the physis.

Coxa vara

It is the second most common complication after AVN in fracture of the femoral neck.[19] Risk of coxa vara is decreased in patients who are treated operatively, and in children <8 years, epiphysiodesis of the greater trochanter is a treatment option.

Conclusion

Paediatric femoral neck fractures are rare fractures, but the potential complications are severe. Orthopedic surgeons should be familiar in managing each type of fracture, to minimize the risk of potentially devastating complications. Delbet classification is reliable and is currently the most preferred fracture classification. Anatomic reduction should be the goal of operative intervention and displaced fractures should be treated urgently (<24 h) to reduce the risk of AVN.

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Conflicts of interest

There are no conflicts of interest.

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