Fractures of the femoral neck in children

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Summary
Femoral neck fractures account for less than 1% of all children’s fractures. They are much rarer than in adults. Delbet classified them from types 1 to 4. Treatment is aimed at reducing the fracture and maintaining the reduction long enough to allow union within 12–16 weeks. Stabilisation of the fracture is most commonly with cannulated screws. Complications include avascular necrosis, coxa vara, non-union, premature physeal arrest and occasionally infection.

Introduction
Femoral neck fractures account for less than 1% of all children’s fractures.1 The femoral neck in children is tough, dense bone with a thick, strong periosteum that requires high-energy trauma to fracture compared to the commonly seen hip fractures in the elderly osteoporotic population. Treatment is aimed at reducing the fracture and maintaining the reduction long enough to allow union within 12–16 weeks.3

Fracture patterns and classification differ in children compared to adults in part due to the different anatomy. A more precarious vascular anastomosis between the femoral neck and head leads to a higher incidence of avascular necrosis (AVN) after displaced fractures within the paediatric population. Growth disturbance is an important complication of surgical fixation due to the presence of the physeal plate.

Anatomy
The proximal femur grows from birth with one proximal femoral physis, which later splits into a lateral greater trochanteric physis and a medial subcapital physis. The lateral physis becomes evident at roughly 1 year of age. The subcapital epiphysis ossifies at 4–8 months of age, with the greater trochanter ossific nucleus appearing at about 4 years of age.6 Fusion of the proximal femoral physis occurs in both sexes at about age 18, while fusion of the trochanteric physis occurs earlier at 16–18 years of age.7 Canale points out that these paediatric anatomical differences are important for two reasons; firstly that the radiographs highlighting the bony elements often fail to demonstrate the cartilage model of the femoral head, neck and trochanter, and secondly that growth arrest is possible after almost any hip fracture due to the large amount of cartilage present in children’s hips.4

The vascular anatomy of the paediatric proximal femur has been studied in-depth due to the high complication rate of AVN occurring in fractures around this area. Chung5 highlighted several points including:

- Ligamentum teres contributes very little blood supply to the head until the age of 8, and as an adult serves only 20%.
- Medial and lateral circumflex metaphyseal vessels that traverse the femoral neck predominately supply the head...
at birth. These later become virtually non-existent by the age of 4 owing to the development of the cartilaginous physis that forms a barrier to these penetrating vessels.

- As the metaphyseal vessels diminish their supply to the femoral head the lateral epiphyseal vessels become the main blood supply as they bypass the physeal barrier. These vessels can be identified as the posteroinferior and posterosuperior branches of the medial circumflex artery which supply the femoral head throughout the rest of its life.

Mechanism of injury

High-energy trauma accounts for most paediatric hip fractures; five large studies found this to be the main cause in approximately 80% of cases,\(^1\),\(^6\)–\(^9\) usually attributable to road traffic accidents or falls from height.\(^9\) Hip fractures caused by low energy trauma should raise suspicion of a pathological fracture; causes include unicameral bone cyst, aneurysmal bone cyst or fibrous dysplasia. Non-accidental injury may rarely be responsible.

Classification

Delbet’s\(^{10}\) simple classification is the most widely used and accepted (approximate percentage of incidence).\(^3\)

Type 1  Transphyseal, with or without dislocation of the femoral head (3%)
Type 2  Transcervical, displaced or undisplaced (50%)
Type 3  Cervico-intertrochanteric (37%)
Type 4  Intertrochanteric (10%)

Treatment

There is no recognised agreed method for treatment of each type of fracture. Ratliff recommended a plaster hip spica to be used to treat undisplaced fractures,\(^1\) although fixation in the older child is more appropriate.

Type 1

Canale\(^4\) advocates that trans-physeal fractures with or without dislocation should be treated with anatomical reduction, followed by secure fixation by way of smooth pins if the patient is less than 3 years of age and threaded screws if older.

Type 2

Internal fixation with threaded or cannulated hip screws was suggested by Canale\(^4\) as the treatment of choice for transcervical fractures even if they are undisplaced.

Type 3

Cervico-trochanteric fractures which are definitely undisplaced can be treated in an abduction hip spica cast\(^4\). However, if displacement is evident then internal fixation

Figure 1  AP pelvis radiograph showing transcervical fracture of the left proximal femur.

Figure 2  Lateral left hip radiograph showing transcervical fracture of the left proximal femur.
should be performed to reduce the risk of coxa vara and possible non-union.

**Type 4**

Intertrochanteric fractures can be treated by skin traction followed by an abduction spica in young children. If the fracture cannot be reduced or maintained by casting then internal fixation with a screw and side plate is necessary. Blockey advocates manipulative reduction, threaded screw fixation and postoperative immobilisation no longer than 4 months for all types of fractures. He states that if manipulative reduction is unsuccessful then open reduction is required, with the interposed soft tissue removed. The final option is a sub-trochanteric osteotomy. Ratliff felt that subtrochanteric osteotomy should be used routinely for displaced type 2 transcervical fractures. Canale concluded that all types 2, 3 and 4 fractures in older children should undergo open reduction and internal fixation whatever the degree of displacement, particularly in the presence of multiple injuries.

**Complications**

The incidence of complications varies between 20% and 60%. It should be noted that the higher figure of 60% occurred in two studies with long-term follow-up of their cases. This suggests that these injuries may well not reveal their full impact until several years after the initial insult.

**Avascular necrosis**

Morsy's study of 53 children found that 40% developed AVN, similar to Ratliff's 42% in his review of 73 cases in 1962. His study revealed no AVN in undisplaced fractures. Type 1 displaced fractures were found to have a 75% chance of developing AVN by Canale and Ng. This is in marked contrast to the low AVN frequency of less than 10% with type 4 displaced fractures. Studies of types 2 and 3 fractures have confirmed that the amount of initial fracture displacement is directly proportional to the risk of AVN due to the compromise of blood supply to the proximal femur at time of the injury. Swiontkowski proposed that this vascular compromise was likely to be due to rupture or kinking of the vessels by the displaced fracture. This lead Swiontkowski, Ng and Cheng to advocate early hip decompression in displaced types 2 and 3 fractures, to successfully reduce the incidence of AVN from 50% to 10%. The decompression was performed at the time of open reduce of the fracture by either aspiration or capsulotomy. Anatomical reduction of displaced fractures was also found to be a significant factor predicting the likelihood of developing AVN by Morsy. He found a decrease from 71% in the non-anatomical reduction group to only 17% in the anatomically reduced group, therefore advising anatomical reduction in every case to reduce the risk of AVN. Several authors conclude that it is these two factors, the initial severity of the trauma and degree of displacement, rather than the mode of treatment that most closely relates to the risk of AVN.

Figures 3 and 4  AP and lateral radiographs 8 weeks postoperatively showing double cannulated screw fixation of the left proximal femur.
Coxa vara

Lam’s most common complication was coxa vara (31%), which is consistent with Morsy’s (36%). Morsy’s affected patients included 11 cases of transcervical fractures and eight patients with basicervical fractures. Togrul found 8% of their cases developed coxa vara but this was confined to the conservatively treated cases. Several studies have found the incidence of coxa vara to be reduced by internal fixation of these injuries.

Non-union

The incidence of non-union varies from 1.6% in Togrul’s review to 36% in Morsy’s study. Morsy comments that this significant increase was probably due to infection in 23% and non-anatomical reduction in 38% of their cases. This would be consistent with Togrul’s series accounting for their low incidence of non-union being due to their high rate of anatomical repositioning.

Premature physeal closure

The incidence of premature physeal closure varies greatly from 6.5% in Ratliff’s to 62% in Canale’s. Morsy found a correlation between AVN and premature physeal closure. If AVN is linked to initial displacement of these fractures it seems reasonable to propose that Canale’s cases may well have undergone more severe initial displacement to cause their increased incidence of premature physeal closure.

If an implant crosses the physis, an increase in the rate of premature physeal closure led Togrul to comment that this complication is mostly a result of an intra-operative error by an inexperienced surgeon. This means that premature physeal closure is linked to both the force of energy involved as well as the use of internal fixation rather than there being an increased incidence related to the fracture type.

Infection

Canale quotes infection as being uncommon. Morsy reported a high rate of infection, stating that 67% of these cases were treated with internal fixation and the rest underwent subtrochanteric osteotomy. He makes no comment in his methods as to whether prophylactic antibiotics were used in these patients.

Cases

Three brief cases are shown which demonstrate different fracture types.

Case 1: Delbet Type 2 fracture in an 8-year-old child with Rett’s syndrome treated with 2 cannulated screws

An 8-year-old girl presented to a local district general hospital having fallen from the edge of a bed from a height of 90 cm. She had a diagnosis of Rett’s syndrome with developmental delay and epilepsy. Her mobility was poor, only able to walk a few steps with the aid of one stick. Following the fall she was unable to weight bear and held her left hip and knee flexed. Radiographs showed generalised osteopenia with a transcervical fracture (Delbet type 2) of the left proximal femur (Figs. 1 and 2). She was transferred to our centre and was treated with reduction under image intensifier and fixation with two 6.5 mm cannulated screws (Figs. 3 and 4), a hip spica for 6 weeks and follow up for 3 years. She was then pain-free with a good range of movement of the hips, although overall mobility was still poor due to the underlying syndrome. There was no evidence of avascular necrosis on subsequent radiographs.

Case 2: cervicotrochanteric fracture (type 3) following a significant fall

A 5-year-old boy with ADHD fell from a first floor window onto concrete. Sustaining a right cervicotrochanteric proximal femur fracture (Delbet type 3) and no other significant

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Figure 6 Lateral radiograph of the right hip showing cervicotrochanteric fracture of the proximal femur.
injuries (Figs. 5 and 6). He was placed in a Thomas splint and transferred to our centre. The fracture was reduced under image intensifier and fixed with three 4.0 mm cannulated screws (Figs. 7 and 8) and protected in a spica cast for 6 weeks. At 16 months postoperatively he was noted to be fully weight bearing with a good range of movement in the hips. There was no evidence of avascular necrosis on subsequent radiographs.

Case 3: Intertrochanteric (type 4) fracture following RTA

A 13-year-old boy was a passenger in a head-on vehicle collision sustaining an intertrochanteric fracture (Delbet type 4) of the left proximal femur and no other significant injuries (Figs. 9 and 10). He was treated with an 80 mm dynamic hip screw and 135° four-hole plate (Figs. 11 and 12). Within 3 weeks he was fully weight bearing without pain.
Proximal femoral fractures in children are uncommon and are usually due to high energy trauma. The presence of growth plates and a precarious blood supply makes them different from adult fractures. Complication rates are high and often do not manifest until several years after the initial fracture management. These patients should therefore be followed up until they reach skeletal maturity.

The high complication rates and rarity of these fractures suggest that ideally only surgical teams with a high degree of experience of paediatric trauma should manage them.

In our experience we would suggest anatomical reduction and fixation with cannulated screws for types 1, 2 and 3 fracture patterns. For management of type 4 intertrochanteric fractures we suggest the use of a sliding screw and side plate.

References