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FRACTURES AND TRAUMATIC DISLOCATIONS OF THE HIP IN CHILDREN

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FRACTURES OF THE HIP

Fractures of the head and neck of the femur in children are exceedingly rare, accounting for fewer than 1% of all pediatric fractures (24). In comparison, the prevalence of fractures of the hip in children is less than 1% of that in adults. Therefore, most orthopaedic surgeons will treat only a few such fractures in a lifetime (16).

The pattern of fracture and thus the classification in children differ from those in adults. Because of the weak proximal femoral physis, a transphyseal separation can occur in children. Transcervical and cervicotrochanteric fractures have an extremely high risk for avascular necrosis (AVN) and coxa vara compared with their adult counterparts. Intertrochanteric fractures are mechanically similar in both groups, although in children involvement of the greater trochanteric apophysis can result in premature closure.

The proximal femoral physis is at risk in hip fracture and has obvious implications for fracture care and prognosis. If the proximal physis is damaged, coxa vara or coxa breva may develop with further growth regardless of fracture alignment. Conversely, if the greater trochanter apophysis fuses prematurely as a result of trauma, coxa valga may develop (4).

Although hip fractures in children can generally be expected to heal, their importance lies in the frequency and severity of complications, including AVN, coxa vara, premature physeal closure, limb length discrepancy and occasionally nonunion. Because the hip is developing in the growing child, deformities can progress with age.

Diagnosis

Mechanism of Injury

Hip fractures in children can be caused by axial loading, torsion, hyperabduction, or a direct blow to the hip. Almost all hip fractures in children are caused by severe, high-energy trauma. This is in marked contrast to hip fractures in the elderly, in whom minor torsional forces acting on osteoporotic bone cause most hip fractures. The proximal femur in children, except for the proximal femoral physis, is extremely strong, and high-energy forces, such as from moving vehicle accidents and high falls, are necessary to cause fracture (9).

Examination

Clinical examination usually reveals pain in the hip and a shortened, externally rotated extremity. With a nondisplaced or stress fracture of the femoral neck, the patient may be able to bear weight with a limp and may only demonstrate hip or knee pain with extremes of range of motion, especially internal rotation. A good quality anteroposterior pelvic radiograph will provide a comparison view of the opposite hip if a displaced fracture is suspected. A cross-table lateral radiograph should be considered to avoid further displacement and unnecessary discomfort to the patient from an attempt at a frog-leg lateral view. Any break or offset of the bony trabeculae near Ward's triangle is evidence of a nondisplaced or impacted fracture.

Not all fractures can be detected on plain radiographs early. Special studies may be required to reveal an occult fracture. A radioisotopic bone scan 48 hours after the onset of symptoms may show increased uptake at the fracture site. The typical magnetic resonance imaging (MRI) appearance of a fracture is a linear black line (low signal) on all sequences surrounded by a high signal band of bone marrow edema and hemorrhage. The low signal represents trabecular impaction. MRI may detect an occult hip fracture within the first 24 hours after injury (17).

In a patient with posttraumatic hip pain without evidence of a fracture, other diagnoses must be considered, including synovitis, hemarthrosis, and infection. A complete blood count, erythrocyte sedimentation rate, C-reactive protein, and temperature are helpful. Ultrasonography can be used to detect fluid in the joint. If necessary, aspiration should be performed. A bloody aspirate establishes the diagnosis of fracture, whereas a serous or suppurative aspirate suggests synovitis or infection, respectively. In children under 5 years of age, developmental coxa vara can be confused with an old hip fracture (4).

Classification

Pediatric hip fractures are classified by the method of Delbet. Its simplicity and uniformity allow accurate description and reporting of results of each fracture by type. Type I is a transepiphyseal separation, with (type IA) or without (type IB) dislocation of the femoral head from the acetabulum. Type II is a transcervical fracture. Type III is a cervicotrochanteric fracture. Type IV is an intertrochanteric fracture (8) (Fig. 21-1). Subtrochanteric fractures are not included in this classification and are discussed in Chapter 22.

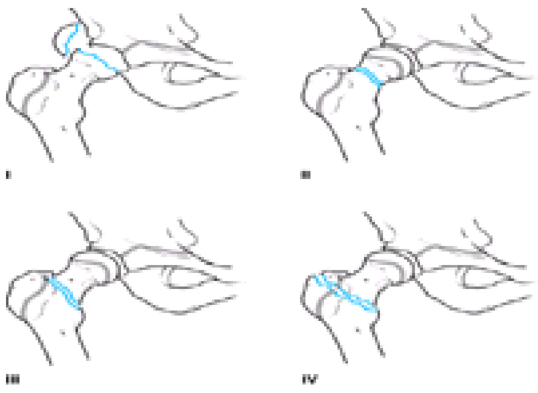

FIGURE 21-1. Delbet classification of hip fractures in children. *I,* transepiphyseal, with or without dislocation from the acetabulum; *II,* transcervical; *III,* cervicotrochanteric; and *IV,* intertrochanteric.

Type I

Transphyseal fractures occur through the proximal femoral physis (Fig. 21-2). Such fractures are rare, constituting 8% of femoral neck fractures in children (16). True transphyseal fractures tend to occur in young children after high-energy trauma (5,12) and are different from unstable slipped capital femoral epiphyses of the preadolescent, which probably occur as a result of a subtle endocrinopathy. In the absence of a history of significant trauma in a young child, battered child syndrome should be suspected (28). Rarely, this injury occurs during a difficult delivery or attempted closed reduction of a traumatic dislocation of the hip in adolescents (16). Approximately half of type I fractures are associated with a dislocation of the capital femoral epiphysis. In such cases, the outcome is dismal because of AVN and premature physeal closure in virtually 100% of patients (5,12).

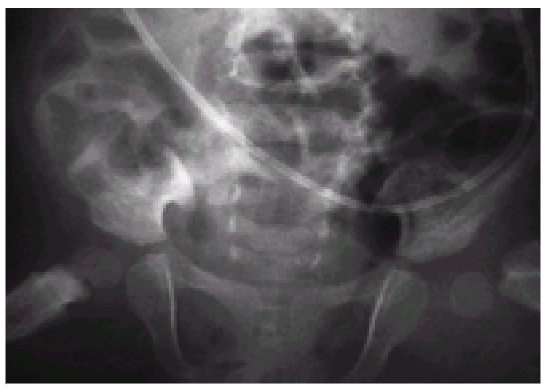

FIGURE 21-2. Type I transphyseal fracture of the left proximal femur in a 3-year-old patient with spina bifida. Superior translation of the metaphysis with the head remaining in the acetabulum is typical of a type IA fracture.

Type I fractures in children under 2 or 3 years of age have a better prognosis than in older children. AVN is unlikely, although coxa vara, coxa breva, and premature physeal closure can cause subsequent leg length discrepancy (18,23).

Type II

Transcervical fractures account for 46% of fractures of the head and neck of the femur in children (16). In three large series, 77% of all type II fractures were displaced (16). Nondisplaced fractures have a better prognosis and a lower rate of AVN than displaced fractures, regardless of treatment (5,24). The risk of AVN is thought by most investigators to be directly related to the initial displacement of the fracture, although a few have hypothesized an intraarticular hemarthrosis with tamponade (5,16) as the etiology of vascular impairment.

Type III

Cervicotrochanteric fractures are, by definition, located at or above the anterior intertrochanteric line and are the second most common type of hip fracture in children, comprising about 34% of fractures (16). The incidence of AVN is 20% to 30%, and, as in type II fractures, the risk of AVN is directly related to the degree of displacement at the time of injury (16). Premature physeal closure occurs in 25% of patients and coxa vara in 14% (16). Displaced type III fractures are similar to type II fractures in regard to the development of complications. Nondisplaced type III fractures have a much lower complication rate than displaced fractures.

Type IV

Intertrochanteric fractures account for only 12% of fractures of the head and neck of the femur in children (16). This fracture has the lowest complication rate of all four types. Nonunion and AVN after this fracture are exceedingly rare. Coxa vara and premature physeal closure have rarely been reported (5,16,19,24,25).

Unusual Fracture Patterns

Type I fracture in a neonate deserves special attention. This injury is exceedingly rare, and, because the femoral head is not visible on plain radiographs, the index of suspicion must be high. An affected infant holds the extremity flexed, abducted, and externally rotated. A strong suspicion, pseudoparalysis, and shortening are keys to the diagnosis. The differential diagnosis includes septic arthritis and hip dislocation. Plain radiographs may be of assistance, but ultrasonography is useful if the diagnosis remains in doubt. Plain radiographs may show a high riding proximal femoral metaphysis on the involved side, resembling a dislocation. Ultrasonography shows the cartilaginous head in the acetabulum with dissociation from the femoral shaft. The diagnosis can be missed if there is no history of trauma (such as in child abuse) or if there is an ipsilateral fracture of the femoral shaft (1).

Stress fractures are caused by repetitive injury and result in hip or knee pain and a limp. Pain associated with long distance running, marching, or a recent increase in physical activity is suggestive of stress fracture. Close scrutiny of high-quality radiographs may identify sclerosis, cortical thickening, or new bone formation. Undisplaced fractures may appear as faint radiolucencies (Fig. 21-3).

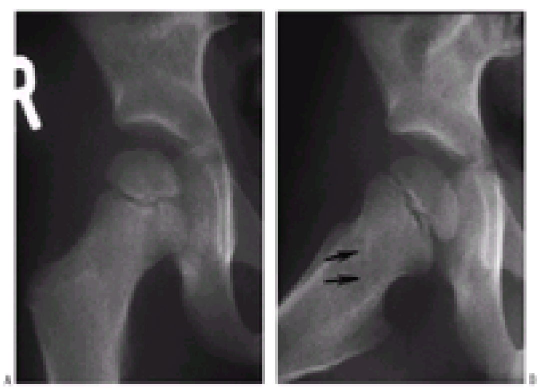

FIGURE 21-3. A: This 5-year-old boy jumped off his bunk bed and subsequently complained of right hip pain and limp. Anteroposterior radiography yielded normal findings. **B:** Careful examination of the frog-leg lateral radiograph revealed a nondisplaced femoral neck fracture. Symptoms resolved after 4 weeks in a spica cast.

An acute unstable slipped capital femoral epiphysis may be confused with an acute type I fracture of the proximal femur; however, a slipped capital femoral epiphysis is caused by an underlying abnormality of the physis and occurs after trivial trauma, usually in preadolescents, whereas type I fractures usually occur in young children.

Fracture after minor trauma suggests weakened bone. Intrinsic bone disease, tumors, cysts, and infections may weaken the bone. If the trauma is significant, but the history is not consistent, nonaccidental trauma must always be considered (2,28).

It is easy to miss hip fractures that are overshadowed by more dramatic or painful injuries. Radiographs of the proximal femur should be examined carefully in patients with femoral shaft fractures because ipsilateral fracture or dislocation of the hip is not unusual (1).

Surgical and Applied Anatomy

Ossification of the femur begins in the 7th fetal week (12). In early childhood, only a single proximal femoral physis exists (Fig. 21-4A and Fig. 21-4B). During the first year of life, the medial portion of this physis grows faster than the lateral, creating an elongated femoral neck by 1 year of age (Fig. 21-4C). The capital femoral epiphysis begins to ossify at approximately 4 months in girls and 5 to 6 months in boys. The ossification center of the trochanteric apophysis appears at 4 years in boys and girls (16) (Fig. 21-4D). The proximal femoral physis is responsible for the metaphyseal growth in the femoral neck, whereas the trochanteric apophysis contributes to the appositional growth of the greater trochanter and less to the metaphyseal growth of the femur (20) (Fig. 21-5). Fusion of the proximal femoral and trochanteric physes occurs at about the age of 14 in girls and 16 in boys (15). The confluence of the greater trochanteric physis with the capital femoral physis along the superior femoral neck (Fig. 21-4E) and the unique vascular supply to the capital femoral epiphysis make the immature hip vulnerable to growth derangement and subsequent deformity after a fracture.

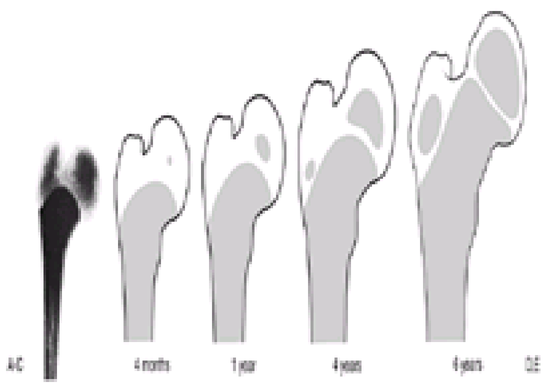

FIGURE 21-4. The transformation of the preplate to separate growth zones for the femoral head and greater trochanter. The diagram shows development of the epiphyseal nucleus in the proximal end of the femur. **A:** Radiograph of the proximal end of the femur of a stillborn female, weight 325 g. **B–E:** Drawings made on the basis of radiographs. (Reprinted from Edgren W. Coxa plana. A clinical and radiological investigation with particular reference to the importance of the metaphyseal changes for the final shape of the proximal part of the femur. *Acta Orthop Scand* 1965;84(suppl):24; with permission.)

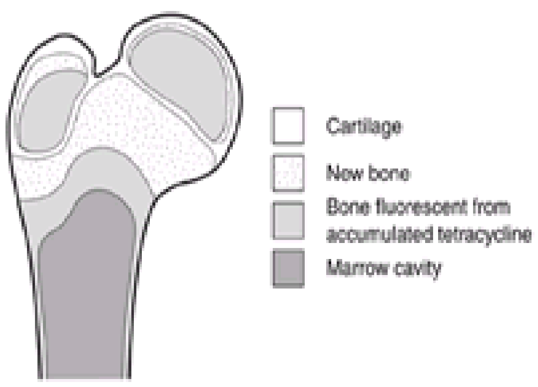

FIGURE 21-5. Drawing of a frontal section through the upper end of the femur of a 14-week-old pig injected 8 weeks previously with tetracycline (50 mg/kg). Diagram depicts the contribution of the capital femoral physis and greater trochanteric physis to new bone formation. (Reprinted from Edgren W. Coxa plana. A clinical and radiological investigation with particular reference to the importance of the metaphyseal changes for the final shape of the proximal part of the femur. *Acta Orthop Scand* 1965;84(suppl):24; with permission.)

Vascular Anatomy

Because of the frequency and sequelae of AVN of the hip in children, the blood supply has been studied extensively (7,23,29,30). Postmortem injection and microangiographic studies have provided clues to the vascular changes with age. These observations are enumerated as follows:

1. The vessels of the ligamentum teres are of virtually no importance. They contribute little blood supply to the femoral head until age 8, and then only about 20% as an adult.
2. At birth, the branches of the medial and lateral circumflex arteries (metaphyseal vessels) traversing the femoral neck predominately supply the femoral head. These arteries gradually diminish in size as the cartilaginous physis develops and forms a barrier that prevents penetration of these vessels into the femoral head. This metaphyseal blood supply is virtually nonexistent by age 4.
3. When the metaphyseal vessels diminish, the lateral epiphyseal vessels predominate and the femoral head is primarily supplied by these vessels, which bypass the physeal barrier.
4. Ogden noted that the lateral epiphyseal vessels consist of two branches, the posterosuperior and posteroinferior branches of the medial circumflex artery (Fig. 21-6). At the level of the intertrochanteric groove, the medial circumflex artery branches into a retinacular arterial system (the posterosuperior and posteroinferior arteries). These arteries penetrate the capsule and traverse proximally (covered by the retinacular folds) along the neck of the femur to supply the femoral head peripherally and proximally to the physis.

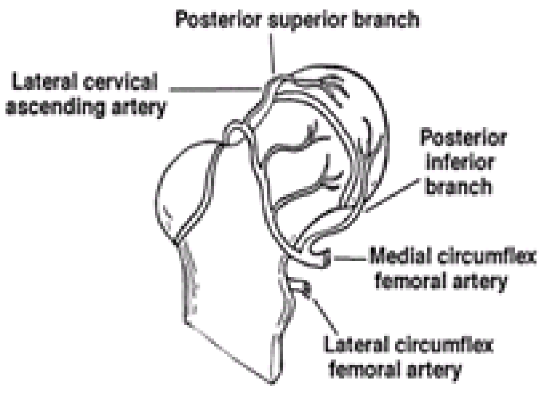

FIGURE 21-6. Arterial supply of the proximal femur. The capital femoral epiphysis and physis are supplied by the medial circumflex artery through two retinacular vessel systems: the posterosuperior and posteroinferior. The lateral circumflex artery supplies the greater trochanter and the lateral portion of the proximal femoral physis and a small area of the anteromedial metaphysis.

5. Capsulotomy does not damage the blood supply to the femoral head, but violation of the intertrochanteric notch or the lateral ascending cervical vessels may render the head avascular.
6. At about 3 to 4 years of age, the lateral posterosuperior vessels appear to predominate and supply the entire anterior lateral portion of the capital femoral epiphysis.
7. The posteroinferior and posterosuperior arteries persist throughout life and supply the femoral head.
8. The multiple small vessels of the young coalesce with age to a limited number of larger vessels. As a result, damage to a single vessel can have serious consequences; for example, occlusion of the posterosuperior branch of the medial circumflex artery can cause AVN of the anterior lateral portion of the femoral head (4).

Soft Tissue Anatomy

The hip joint is enclosed by a thick fibrous capsule. Tense hemarthrosis after intracapsular fracture may tamponade the ascending cervical vessels and may have implications in the development of AVN. The hip joint is surrounded on all sides by a protective cuff of musculature. Open hip fracture is rare. In the absence of associated hip dislocation, neurovascular injuries are rare after hip fracture and are more likely to occur during surgery.

The lateral femoral cutaneous nerve lies in the interval between the tensor and sartorius muscles and supplies sensation to the lateral thigh. This nerve must be identified and preserved during an anterolateral approach to the hip. The femoral neurovascular bundle is separated from the anterior hip joint by the iliopsoas. Thus, any retractor placed on the anterior acetabular rim should be carefully placed deep to the iliopsoas to protect the femoral bundle. Inferior and medial to the hip capsule, coursing from the deep femoral artery toward the posterior hip joint, is the medial femoral circumflex artery. Placement of a distal Hohmann retractor too deeply can tear this artery, and control of the bleeding may be difficult.

The sciatic nerve emerges from the sciatic notch beneath the piriformis and courses superficial to the external rotators and the quadratus medial to the greater trochanter. The nerve is rarely seen at hip fracture surgery, but placement of a Hohmann retractor dorsally and distally, simultaneous with external rotation of the leg, can damage it.

Treatment

Type I

Fracture treatment is based on the age of the child and fracture stability after reduction. In toddlers under 2 years of age with nondisplaced or minimally displaced fractures, simple spica cast immobilization is likely to be successful. Because the fracture tends to displace into varus and external rotation, the limb should be casted in mild abduction and neutral rotation to prevent displacement. Displaced fractures in toddlers should be reduced closed by gentle traction, abduction, and internal rotation. If the fracture "locks on" and is stable, casting without fixation is indicated. If the fracture is not stable, it should be fixed with small smooth pins that access the femoral neck and cross the physis. If casting without fixation is done, repeat radiographs should be taken within days to look for displacement because the likelihood of successful repeat reduction decreases rapidly with time and healing in a young child (Fig. 21-7).

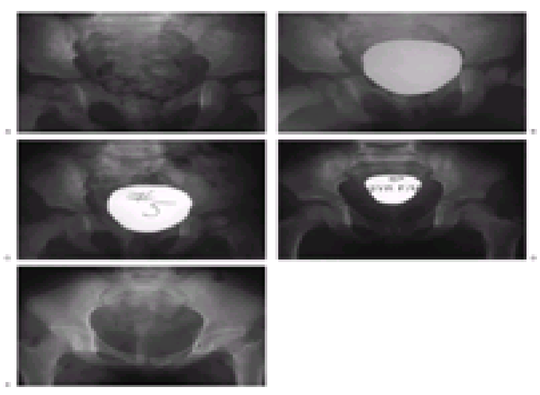

FIGURE 21-7. A: A 16-month-old boy with a type I fracture of the left hip. Note widening of the left femoral physis. **B:** Lateral radiograph at injury. Instability of the physis is apparent. **C:** Anteroposterior radiograph after 1 month in spica cast. **D:** At 2 years postinjury, the patient has mild coxa valga and coxa breva. **E:** At 10 years postinjury, coxa breva secondary to premature physeal closure is evident. Note the overgrowth of the greater trochanter.

Older children should always have operative fixation even if the fracture is undisplaced because the complications of late displacement may be great. Smooth pins can be used in young children, but cannulated screws are better for older, larger children. Fixation should cross the physis into the capital femoral epiphysis. Irreducibility mandates an open reduction and internal fixation. Postoperative spica cast immobilization is mandatory in all but the oldest and most reliable adolescents. Fixation may be removed shortly after fracture healing (8–12 weeks) to enable further growth in younger patients.

Closed reduction of type IB fracture–dislocations should be attempted, with immediate open reduction if unsuccessful. Internal fixation is mandatory. The surgical approach should be from the side to which the head is dislocated, generally posterolateral. Parents must be advised in advance about the risk of AVN.

Type II and Type III

Displaced neck fractures should always be treated with anatomic reduction and stable internal fixation to minimize the risk of late complications. In two large series, the prevalences of coxa vara and nonunion were high in displaced transcervical fractures treated with immobilization but without internal fixation (5,19). Much lower prevalences of these two complications have been documented in patients treated with anatomic closed or open reduction and internal fixation (5).

Internal fixation is also recommended by most investigators for nondisplaced transcervical fractures (16), because the risk of late displacement in such fractures far outweighs the risk of percutaneous screw fixation, especially in young children (3). Nondisplaced type II fractures in children under 5 years of age can be managed with spica casting and close follow-up (10,19), but fixation remains preferable. Even then, close follow-up is necessary to prevent varus displacement in the cast.

Gentle closed reduction of displaced fractures is accomplished with the use of longitudinal traction, abduction, and internal rotation. Open reduction is frequently necessary for displaced fractures and should be performed via a Watson-Jones surgical approach.

Internal fixation with cannulated screws is performed through a small lateral incision. Three screws should be placed if possible. One screw should be placed low along the calcar, and two above, spaced as widely as possible (3). Occasionally, the small size of the child's femoral neck will accommodate only two screws. Care should be taken to minimize drill holes in the subtrochanteric region because they increase the risk of subtrochanteric fracture. If possible, screws should be inserted short of the physis in type III fractures; however, if physeal penetration is necessary for purchase, it must be done (Fig. 21-8 and Fig. 21-9). The risks of premature physeal closure and trochanteric overgrowth are much less than those of nonunion, pin breakage, and AVN. Treatment of the fracture is the first priority, and any subsequent growth disturbance and leg length discrepancy (LLD) are secondary.

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FIGURE 21-8. A: A girl 4 years and 4 months of age with a type II fracture of the left femoral neck. Anteroposterior pelvis film at presentation shows a displaced femoral neck fracture. **B:** Three weeks postinjury. Smooth pins were chosen to minimize the risk of physeal damage. **C:** Six years after fracture. Mild coxa valga is evident, possibly from damage to the growth zone on the superior femoral neck in this young child.

FIGURE 21-9. A: This boy 4 years and 9 months of age sustained a type III femoral neck fracture in a motor vehicle accident. **B:** Lateral radiograph at presentation. **C:** Three months after anatomic open reduction and internal fixation with two screws, sparing the physis. **D:** Lateral radiograph on the same date.

Nondisplaced cervicotrochanteric fractures can be treated adequately in an abduction one and one-half spica cast with close follow-up (16). Displaced cervicotrochanteric fractures have been shown to have a complication rate similar to that for type II fractures and should be treated similarly. Fixation generally does not need to cross the physis in type III fractures.

In a more distal cervicotrochanteric fracture, especially in a child over 5 years of age, a pediatric hip compression screw can be used for more secure fixation. Consideration may be given to capsulotomy or aspiration of the joint to eliminate tense hemarthrosis at the time of surgery. Spica casting is routine, except in older reliable children. Hardware removal at 6 to 12 months after fracture union will avoid bony overgrowth of the hardware.

Type IV

Good results can be expected after closed treatment of most intertrochanteric fractures, regardless of displacement. Traction and spica cast immobilization are effective (16). Failure to maintain adequate reduction and polytrauma are indications for internal fixation. Children old enough to use crutches or those with multiple injuries can be treated with open reduction and internal fixation (Fig. 21-10 and Fig. 21-11). A pediatric hip screw provides the most rigid internal fixation for this purpose.

FIGURE 21-10. A: A girl 3 years and 7 months of age with type IV intertrochanteric right femur fracture. **B:** Three months after fixation with a pediatric sliding hip screw.

FIGURE 21-11. A: A 14-year-old boy who fell from a tree swing sustained this nondisplaced left intertrochanteric hip fracture. **B:** Lateral radiograph shows the long

spiral fracture line. **C:** Three months postfixation with an adult sliding hip screw.

Surgical Procedures

When an operation is indicated, several factors must be evaluated before the method of internal fixation and the operative procedure are selected (Table 21-1). Perhaps the most important consideration is the age of the patient. For discussion, three age-groups have been established arbitrarily: infantile (younger than three years), juvenile (three to eight years), and adolescent (older than eight years).

Anterolateral approach
Age 0–3 yr—smooth pins, 5/64-inch or 3/32-inch
Age 3–8 yr—cannulated 4.5-mm screws
Age 8+ yr—6.9 or 7.3-mm cannulated screws
Type IV fractures
<8 yr—pedi hip compression screw
>8 yr—adult hip compression screw
Always predrill and tap before inserting screws
Avoid crossing physis if possible, but cross physis if necessary for stability
Age <10 yr—hip spica for 6–12 wk

TABLE 21-1. SURGICAL TIPS AND PEARLS FOR FRACTURES IN CHILDREN

For younger and smaller patients, the operation should be done on a radiolucent operating table rather than on a fracture table, which is more appropriate for older and larger adolescents.

For internal fixation of types I, II, and III fractures of the femoral neck, smooth pins may be used in infants; cannulated 4.0-millimeter screws, in children; and cannulated 6.5-millimeter screws, in adolescents. For fixation of type-IV fractures, pediatric-size hip-compression screws should be used in children and adult-size hip-compression screws, in adolescents.

A hip-spica cast should supplement internal fixation in all patients who are less than ten years old. Fractures of the neck of the femur in children who are twelve years old or more are treated in a manner similar to that used in adults: no postoperative cast is used and early walking with crutches is encouraged. For patients who are between the ages of ten and twelve years, the necessity for a postoperative cast is less clear-cut. If stability of the fracture fixation is questionable, or if compliance of the patient is doubtful, a hip-spica cast should be used.

Because the femoral bone in children is harder than the osteoporotic bone in elderly patients, pre-drilling and pre-tapping are necessary for insertion of all screws.

Finally, growth of the femur and the contribution of the proximal femoral physis are important; however, this physeal contribution to growth is only 13 per cent of the entire extremity, or three to four millimeters per year on the average. Once the decision for internal fixation of a fracture of the head or neck of the femur is made, stable fixation of the fracture is a higher priority than preservation of the physis. If stability is questionable, the internal fixation device should extend into the femoral head for rigid, stable fixation, regardless of the type of fracture or the age of the child.

Anterolateral Approach

If closed reduction is successful, a 5- to 4.5-cm lateral incision is made distal to the greater trochanter apophysis for insertion of pins or cannulated screws. An anterior approach through the Watson-Jones interval is often used for open reduction. A lateral incision is made over the proximal femur, slightly anterior to the greater trochanter (Fig. 21-12A). The fascia lata is incised longitudinally (Fig. 21-12B). The innervation of the tensor muscle by the superior gluteal nerve is 2 to 5 cm above the greater trochanter and care should be taken not to damage this innervation. The tensor muscle is reflected anteriorly. The interval between the gluteus medius and the tensor muscles will be used (Fig. 21-12C). The plane is developed between the muscles and the underlying hip capsule. If necessary, the anteriormost fibers of the gluteus medius tendon can be detached from the trochanter for wider exposure. After clearing the anterior hip capsule, longitudinal capsulotomy is made along the anterosuperior femoral neck. A transverse incision may be added superiorly for wider visualization (Fig. 21-12D).

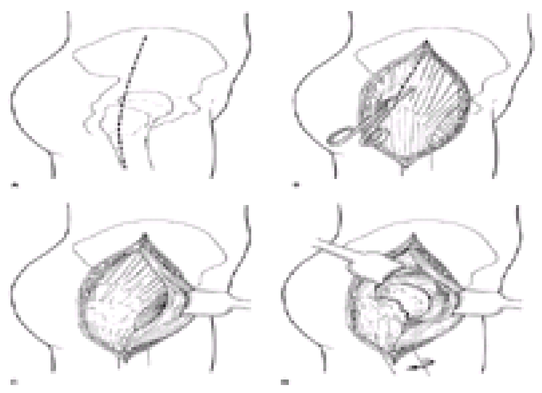

FIGURE 21-12. Watson-Jones lateral approach to the hip joint for open reduction of femoral neck fractures in children. **A:** Skin incision. **B:** Interval between gluteus medius and tensor fasciae. **C:** Dissection carried proximally. **D:** Completed exposure.

Alternatively, a bikini approach can be used through the Smith-Petersen interval. Care should be taken to identify and protect the lateral femoral cutaneous nerve. The sartorius and rectus muscles can be detached to expose the hip capsule. Medial and inferior retractors should be carefully placed to avoid damage to the femoral neurovascular bundle and medial femoral circumflex artery, respectively. Care must be taken not to violate the intertrochanteric notch and the lateral ascending vessels.

Under direct vision, the fracture is reduced and guidewires are passed from the lateral aspect of the proximal femur up the neck perpendicular to the fracture. Wires are passed either through the incision or percutaneously if a bikini approach is used. Smooth wires can be used as definitive fixation in toddlers or as guides for drilling if cannulated screws are used. The choice of internal fixation should consider the child's size and age. For internal fixation of types I, II, and III fractures, smooth pins are appropriate in children under 3 years of age, cannulated 4.5-mm screws in children 3 to 8 years of age, and 6.5-mm cannulated screws in children over 8 years of age. For fixation of type IV fractures, simple screw fixation is inappropriate. A pediatric-size hip compression screw is appropriate in patients under 8 years of age, and an adult-size hip compression screw may be used in older children and adolescents. Because the femoral neck in children is denser and harder than the osteoporotic bone in elderly patients, predrilling and tapping are necessary before the insertion of screws.

Postoperative Fracture Care

Hip spica casting is used after internal fixation in most patients under 10 years of age. The cast should remain in place for 6 to 12 weeks depending on age. For children over 12 years of age, no postoperative cast is used, and early walking with crutches is encouraged, as in adults. For children 10 to 12 years of age, the use of a postoperative cast depends on the stability of fracture fixation and the patient's compliance. If either is in doubt, a single hip spica cast is used. Formal rehabilitation usually is unnecessary unless there is a severe persistent limp, which may be due to abductor weakness. Stiffness rarely is a problem in the absence of AVN.

Complications

Avascular Necrosis

Avascular necrosis is the most serious and frequent complication of hip fractures in children. Its overall prevalence is approximately 30% based on nine series in the literature (6,16,22). It is the primary cause of poor results after fractures of the hip in children. The risk of AVN is related to the extent of initial displacement of the fracture and to the damage to the blood supply at injury. The risk of AVN is highest after displaced type IB, type II, and type III fractures (16) (Fig. 21-13). Although prompt reduction of displaced fractures may be of some benefit, its worth has not been proven. Increased intraarticular pressure caused by fracture hematoma may be related to AVN after intracapsular fracture, and evacuation of this hemarthrosis may decrease the AVN rate (16,22,27). Aspirating the hematoma from the hip capsule may decrease the intracapsular pressure and increase blood flow to the femoral head (6,22) or may have no effect (16,21). If a child is going to have an anesthetic for treatment of a fracture, aspiration of the hematoma can easily be accomplished. Open reduction results in capsular evacuation at capsulotomy, or a small capsulotomy can be made if a straight lateral incision is used after unsuccessful closed reduction.

FIGURE 21-13. A: A 14-year-old girl with a type II fracture of the left femoral neck. **B:** After fixation with three cannulated screws. **C:** Seven months after injury. Avascular necrosis with collapse of the superolateral portion of the femoral head. **D:** After treatment with valgus osteotomy.

Avascular necrosis has been classified by Ratliff as follows: type I, involvement of the whole head; type II, partial involvement of the head; and type III, an area of AVN from the fracture line to the physis (24) (Fig. 21-14). Type I is the most severe and most common form and has the poorest prognosis. Type I probably results from damage to all of the lateral epiphyseal vessels, type II from localized damage to one or more of the lateral epiphyseal vessels near their insertion into the anterolateral aspect of the femoral head, and type III from damage to the superior metaphyseal vessels. Type III is rare but has a good prognosis (24).

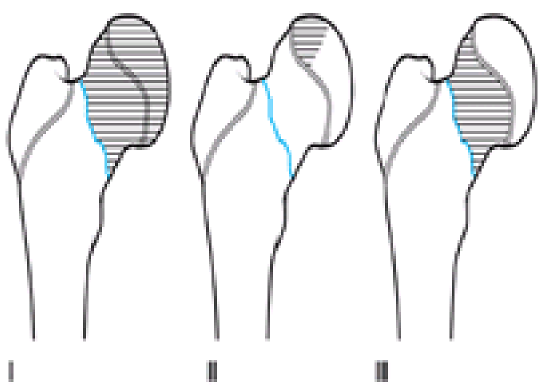

FIGURE 21-14. Three types of avascular necrosis. (Reprinted from Ratliff AHC. Fractures of the neck of the femur in children. *J Bone Joint Surg [Br]* 1962;44:528; with permission.)

Avascular necrosis causes pain and limitation of motion. As early as 6 weeks after injury, plain radiographs may reveal decreased density of the femoral head with widening of the joint space. Fragmentation and collapse of the femoral head occur late. Technetium bone scanning with pinhole collimation may show decreased uptake in the involved femoral head early in the course of AVN. With revascularization, changes may be variable. Signs and symptoms of AVN usually develop within the first year after injury, but sometimes as late as 2 years (16,25). Patients should be followed with plain radiographs for at least 2 years after fracture to rule out late onset of AVN. MRI reveals AVN within a few days of injury (see the subsection on Avascular Necrosis later under Hip Dislocations in Children). If MRI does not reveal AVN within 6 weeks of injury, it is unlikely to develop. The long-term results of AVN are poor in over 60% of patients (5,10,13). There is no clearly effective treatment for posttraumatic AVN in children (16,25). Older children (>10 years of age) tend to have worse outcomes than younger children. Ongoing investigative research includes the role of core decompression, vascularized fibular grafting, and the trapdoor procedure. Results of the procedures in few reported patients must ultimately be compared with the natural healing of untreated AVN. Remodeling can occur over many years and is more likely in younger children than in older ones. Degenerative arthrosis in older children is generally irreversible. Valgus intertrochanteric osteotomy may improve coxa vara and leg length discrepancy if there is reasonable congruence in adduction of the hip preoperatively (Fig. 21-15).

FIGURE 21-15. A: A girl 9 years and 4 months of age with Ratliff type I avascular necrosis of the femoral head. **B:** Lateral radiograph on the same date. The patient has had a previous acetabular osteotomy for containment. **C:** Two years after valgus osteotomy. **D:** Lateral radiograph on same date. Note that some remodeling of the femoral head has occurred.

Coxa Vara

The prevalence of coxa vara has been reported to be approximately 20% to 30% in nine series (16), although it is significantly lower in series in which internal fixation was used after reduction of displaced fractures (5). Coxa vara may be caused by malunion, AVN, premature physeal closure, or a combination of these problems (Fig. 21-16). Severe coxa vara raises the greater trochanter in relation to the femoral head, causing shortening of the extremity and mechanical disadvantage of the abductors. The result is an abductor lurch. If the child is over 8 years of age, the neck shaft angle is 110 degrees or less, and coxa vara has been persistent for more than 2 years, subtrochanteric valgus osteotomy may be considered to restore limb length and abductor strength (16).

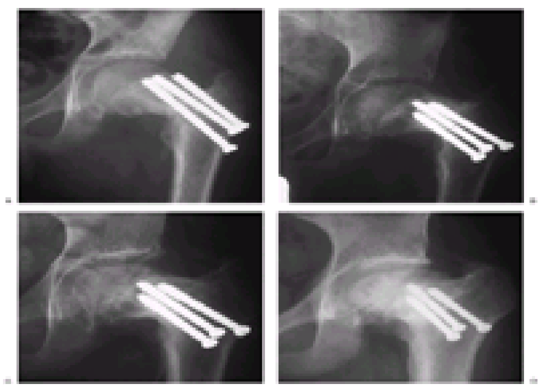

FIGURE 21-16. A: A 12-year-old boy with a type III left hip fracture. Poor pin placement and varus malposition are evident. **B:** The fracture united in mild varus after hardware revision. **C:** Fourteen months after injury. Collapse of the weight-bearing segment is evident (Ratliff type II avascular necrosis). **D:** Six years postinjury. Coxa breva and trochanteric overgrowth are seen secondary to avascular necrosis, malunion, and premature physeal closure.

Premature Physeal Closure

Premature physeal closure has occurred after approximately 28% of fractures (16). The risk of premature physeal closure increases with penetration by fixation devices or when AVN is present. It is most frequent in patients who have type II or III AVN (24,25) (Fig. 21-16).

The capital femoral physis contributes only 13% of the growth of the entire extremity and normally closes earlier than most of the other physes in the lower extremity. As a result, shortening due to premature physeal closure is not significant except in very young children (16,18). Treatment for leg length discrepancy is only indicated for significant discrepancy (2.5 cm or more projected at maturity) (16). Rarely, trochanteric epiphysiodesis may be used in progressive coxa vara.

Nonunion

Nonunion occurs infrequently, with an overall incidence of 7% of hip fractures in children (16). Nonunion is a complication of femoral neck fracture and is not generally seen after type I or type IV fractures. The primary cause of nonunion is failure to obtain or maintain an anatomic reduction (5,16). After femoral neck fracture in a child, pain should be gone and bridging new bone should be seen at the fracture site by 3 months after injury. A computed tomography (CT) scan may be helpful to look for bridging bone. If no or minimal healing is seen by 3 months, the diagnosis of nonunion is established. Nonunion should be treated operatively as soon as possible. Either rigid internal fixation or subtrochanteric valgus osteotomy should be performed to allow compression across the fracture (Fig. 21-17). Because the approach necessary for bone grafting is extensive, it should be reserved for recalcitrant cases. Internal fixation should extend across the site of the nonunion, and spica cast immobilization should be used in all but the most mature and cooperative adolescents.

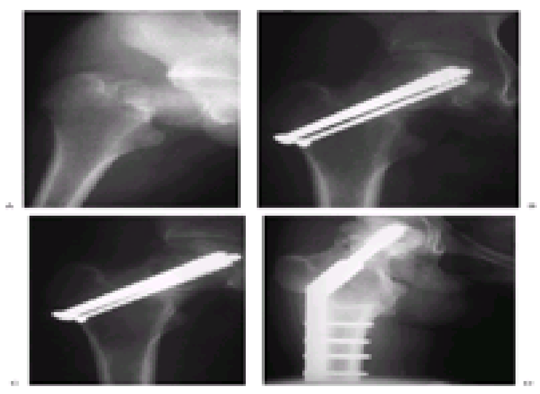

FIGURE 21-17. A: A 15-year-old girl with a markedly displaced type II femoral neck fracture. **B:** She underwent open reduction and internal fixation with two 7.3-mm cannulated screws and one 4.5-mm cannulated screw. Primary bone grafting of a large defect in the superior neck also was performed. **C:** Radiograph at 5 months showing a persistent fracture line. **D:** Six weeks after valgus intertrochanteric osteotomy. The fracture is healing.

Other Complications

Infection is uncommon after hip fractures in children. The reported incidence of 1% (5,19,24) is consistent with the expected infection rate in any closed fracture treated surgically with open reduction and internal fixation.

Chondrolysis is exceedingly rare and has been reported only in one series at a rate of 50% (13). Care must be taken to avoid persistent placement of hardware into the joint, which can cause this condition.

Stress Fractures

Stress fractures of the femoral neck are unusual in children. Only 13 cases have been reported in the English-language literature. The rarity of such fractures underscores the need for a high index of suspicion when a child has unexplained hip pain, because early diagnosis and treatment are essential to avoid complete fracture with displacement.

Mechanism

Stress fractures of the femoral neck in children result from repetitive cyclic loading of the hip, such as that produced by a new or increased activity. A recent increase in the repetitive activity is highly suggestive of the diagnosis. Long distance running, trampoline use, and scooter use are examples of such activities. Underlying metabolic disorders that weaken the bone may predispose to stress fracture. In adolescent female athletes, amenorrhea, anorexia nervosa, and osteoporosis have been implicated in the development of stress fractures of the femoral neck (14).

The usual presentation is that of progressive hip or groin pain with or without a limp. The pain may be perceived in the thigh or knee, and the pain may not be so severe as to preclude the offending activity. In the absence of displacement, examination typically reveals slight limitation of hip motion with increased pain, especially with internal rotation. Usually, plain radiographs reveal the fracture, but in the first 4 to 6 weeks after presentation, plain films may be negative. If there are no changes or only linear sclerosis, bone scan will help identify the fracture. MRI has been documented as a sensitive test for undisplaced fractures of the femoral neck because impaction of the bony trabeculae appears on both T1 and T2 images as a linear black signal (21). If a sclerotic lesion is seen on plain radiographs, the differential diagnosis should include osteoid osteoma, chronic sclerosing osteomyelitis, bone infarct, and osteosarcoma. Other causes of hip pain, including slipped capital femoral epiphysis, Legg-Calve-Perthes disease, infection, avulsion injuries of the pelvis, and eosinophilic granuloma should be considered. Stress fracture unrelieved by rest or treatment may progress with activity to complete fracture with displacement (26). For this reason, prompt diagnosis and treatment are important.

Classification

Devas classified femoral neck stress fractures into two types: compression fractures and tension fractures. The compression type appears as reactive bone formation on the inferior cortex without cortical disruption. This type rarely becomes completely displaced but may collapse into a mild varus deformity (11). Compression types have recently been reported to progress to complete fracture without early treatment (26). The tension type is a transverse fracture line appearing on the superior portion of the femoral neck (11). This type is inherently unstable because the fracture line is perpendicular to the lines of tension and fractures heal best under compression. Tension stress fractures have not been reported in children but may occur in the skeletally mature teenager (26).

Treatment

Compression type fractures generally can be treated with a period of non–weight bearing on crutches. Partial weight bearing can be allowed at 6 weeks and full weight bearing at 12 weeks if pain is resolved and there is radiographic evidence of healing. In small or uncooperative children, spica casting may be necessary. Displacement into varus, however minimal, mandates internal fixation. Tension fractures are at high risk for displacement and should be treated with *in situ* compression fixation using cannulated screws (Fig. 21-18).

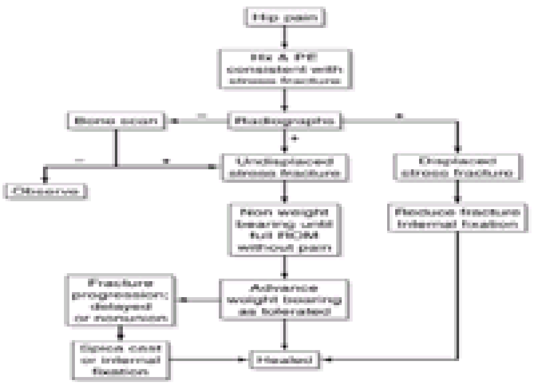

FIGURE 21-18. Treatment algorithm for hip pain in children and adolescents with a history and physical examination compatible with a stress fracture. (Reprinted from St. Pierre P, Staheli LT, Smith JB, et al. Femoral neck stress fractures in children and adolescents. *J Pediatr Orthop* 1995;15:470–473.

Complications

Coxa vara is the most common complication of untreated compression type fractures. Acute displacement of this type also has been described. Once displaced, the stress fracture is subject to all the complications of type II and type III displaced femoral neck fractures.

HIP DISLOCATIONS IN CHILDREN

Hip dislocations in children are relatively uncommon. They can occur in young children under age 5 as a result of seemingly trivial trauma (32,37,43,46,51). The child's acetabulum at that age is primarily soft pliable cartilage, and there is generalized ligamentous laxity that allows hip dislocation. Dislocations in older children usually require significant trauma because the acetabulum is bony and less resilient and the ligaments are stiffer (37,43,46,51). Most hip dislocations in children can be reduced easily and will heal satisfactorily (46,51), although the possibility of late problems exists (50). Difficulties after hip dislocation can include neurovascular injury, concomitant fracture, irreducibility, nonconcentric reduction, AVN, coxa magna, arthrosis, and recurrent dislocation.

Diagnosis

The mechanism of injury dictates the direction of hip dislocation. Posterior dislocations are the most common (32,50,51) and generally occur when a force is applied to the leg with the hip flexed. Anterior dislocations generally occur through a combination of external rotation and abduction.

The affected child has pain and inability to ambulate. Children sometimes feel the pain in the knee rather than in the hip (Fig. 21-19). The hallmark of the clinical diagnosis of dislocation of the hip is abnormal positioning of the limb, which is not seen in fracture of the femur. With posterior dislocation, the thigh tends to be flexed, adducted, and internally rotated. The greater trochanter is proximal to its normal position, and the femoral head is often palpable in the gluteal region. If the hip is dislocated anteriorly, the extremity is generally extended, abducted, and externally rotated. Posterior dislocations of the femoral head can damage the sciatic nerve, and function of this nerve should be specifically tested after injury. Anterior dislocations can damage the femoral neurovascular bundle, and femoral nerve function and perfusion of the limb should be assessed.

FIGURE 21-19. A: Not all children have severe pain with dislocation. An 8-year-old complained of pain and had difficulty walking after wrestling. Because of knee pain, a knee immobilizer was placed at an outside facility. **B:** The leg length discrepancy had gone unnoticed. **C:** The thigh was markedly shortened on the dislocated right side. **D:** Closed reduction was easily achieved under anesthesia. Thigh length was restored. She made an unremarkable recovery.

Plain radiographs usually confirm the diagnosis. Radiographs should be examined for fracture of the acetabular rim and proximal femur, which may be associated with dislocation. Ipsilateral femoral fracture has been described in a few patients (50). CT scanning is useful for evaluating the acetabulum and may be useful in localizing intraarticular bony fragments after reduction (44) (Fig. 21-20). The identification of nonbony fragments is difficult by CT without the use of concomitant arthrography (44). MRI is useful for evaluating soft tissues that may be interposed between the femoral head and acetabulum. MRI is especially helpful in nonconcentric reductions when the initial direction of dislocation is unknown. Soft tissue injury will dictate the surgical approach.

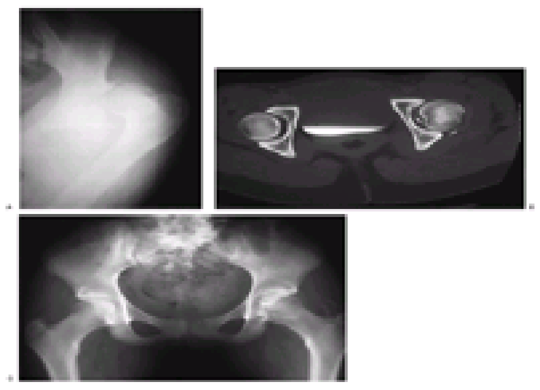

FIGURE 21-20. A: A girl 13 years and 11 months of age sustained a left posterior hip dislocation in a motor vehicle accident. **B:** Computed tomography scan after reduction showed intraarticular bony fragments. **C:** At open reduction and capsulorrhaphy, the bony fragments were removed. Suture anchors were used to reattach capsule to bone. Ten months postinjury, there is no sign of avascular necrosis. Heterotopic ossification is seen.

Spontaneous reduction may occur after hip dislocation (47), and the diagnosis will be missed if it is not considered. The presence of air in the hip joint, which may be detectable on CT scan of the pelvis, is evidence that a hip dislocation has occurred (36). Dislocation and spontaneous reduction with interposed tissue can occur and lead to late arthropathy if untreated (47). Widening of the joint space on plain radiographs suggests the diagnosis. In patients with hip pain, a history of trauma, and widening of the joint space, consideration should be given to MRI or arthrography to rule out dislocation with spontaneous relocation incarcerating soft tissue. If incarcerated soft tissues or osseous cartilage fragments are found, open reduction is required to obtain concentric reduction of the hip.

Classification

Hip dislocations in children generally are classified as anterior or posterior depending on where the femoral head lies after dislocation. Posterior dislocations are much more common than anterior dislocations and tend to occur as a result of an axial force on the femur applied toward the hip with the hip in flexion. Dashboard injury is a frequent cause. The limb assumes a position of shortening, internal rotation, and adduction (Fig. 21-21).

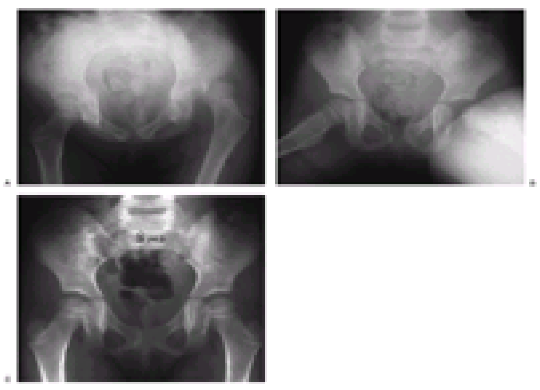

FIGURE 21-21. A: A girl 4 years and 7 months of age presented with a posterior dislocation of the left hip. **B:** Frog-leg lateral radiograph at injury is shown. **C:** Eight months after successful closed reduction, radiographic appearance is normal.

Anterior dislocations can occur superiorly or inferiorly and result from forced abduction and external rotation. In extension, the hip tends to dislocate anteriorly and superiorly. The limb appears shortened, the thigh is positioned in external rotation and extension and the femoral head is palpable in the groin. If the hip dislocates with the leg flexed, the femoral head tends to dislocate inferiorly. The leg is held in abduction, external rotation, and flexion, and the femoral head is palpable near the obturator foramen (Fig. 21-22).

FIGURE 21-22. A: An 11-year-old girl sustained anterior inferior dislocation of the hip. **B:** Immediate closed reduction was concentric.

Fracture–dislocation of the hip involving the femoral head or the acetabulum is much more unusual in children than in adults. Older adolescents may sustain adult-type fracture–dislocations of the hip, and these are best classified by the methods of Thompson and Epstein and of Pipkin.

Unusual Fracture Patterns Associated with Hip Dislocation

There are several pitfalls in the diagnosis of hip dislocations in children. It is always important to look for associated fractures. In older children, it is important to evaluate the posterior rim of the acetabulum after posterior dislocation to rule out fracture (Fig. 21-23). Fractures at other sites in the femur must be considered. It is important to obtain radiographs that show the entire femur to rule out ipsilateral fracture. Fractures of the femoral head are distinctly unusual in children, but separation of the capital femoral epiphysis and femoral neck fracture have been reported in association with dislocation of the hip.

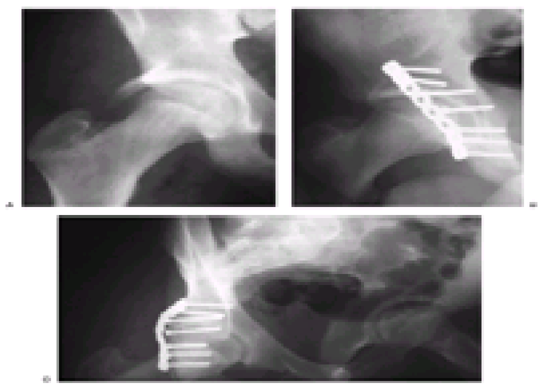

FIGURE 21-23. A: A 12-year-old boy was tackled from behind in football. The right hip was dislocated. Reduction was easily achieved, but the hip was unstable posteriorly as a result of fracture of the posterior rim of the acetabulum. **B:** The fracture and capsule were fixed via a posterior approach. **C:** Oblique view shows reconstitution of the posterior rim.

Another pitfall is the possibility of spontaneous relocation of a dislocation of the hip. Failure to appreciate the presence of hip dislocation may lead to inadequate treatment. If soft tissue has been interposed in the hip joint, chronic arthropathy may result. In a child with posttraumatic hip pain without obvious deformity, the possibility of dislocation–relocation must be considered. Radiographs should be obtained to rule out joint space widening and undisplaced fracture.

Another consideration after reduction of hip dislocations is interposed tissue. After reduction, hemarthrosis may initially cause the hip joint to appear slightly wide (49). With time, the hip should seat and the increased iliofemoral distance should subside (Fig. 21-24). If it fails to appear concentric after a few days, the possibility of interposed soft tissue must be considered (39,43,47,52).

FIGURE 21-24. A: A boy 10 years and 3 months of age sustained an anterior dislocation of the hip in football. **B:** The hip was easily reduced. The joint space was initially widened, probably due to hemarthrosis but normalized in a few days. **C:** At 4 months postinjury, the radiographic appearance was normal.

Surgical and Applied Anatomy

The hip joint is highly specialized. Although capable of bearing body weight, the hip still provides a tremendous range of motion, surpassed only by the range of motion of the shoulder. The architecture of the hip joint is highly specialized and is centered on the spherical femoral head, which resides in the bony acetabulum. The relatively narrow femoral neck increases the range of motion possible at the hip joint in flexion, extension, abduction, and circumduction. A larger diameter neck would impinge on the acetabular rim at extremes of motion.

Containment of the hip joint is assured by several factors. The bony socket physically constrains the femoral head and is further deepened by the surrounding fibrocartilaginous acetabu- lar labrum. In young children, the socket and labrum are largely cartilaginous and flexible. In older children, a larger proportion of the socket and rim is hard bone. Intimate contact between the cartilaginous surfaces of the round head and the socket, in the presence of joint fluid, provides a suction fit. In an intact joint, considerable force is required to disrupt this union. The strong fibrous joint capsule further contains the hip joint. The capsule is flexible enough to allow excellent range of motion, but secure enough to maintain the hip reduced except for extreme circumstances. The ligamentum teres does not provide any stability to the hip. The muscles that span the hip joint further provide active extrinsic stability by maintaining constant tension across the hip joint, which pushes the head into the acetabulum. These muscles, which provide the power for standing and locomotion, act around the fulcrum centered at the hip. Efficient transmission of muscle forces requires hip stability.

In order for the hip to dislocate, considerable force or mechanical advantage is required to overcome these restraints. The capsule must be torn or stretched. This will be deformed or disrupted at the time of dislocation. The ligamentum teres is likely to be torn, but this does not appear to result in any long-term sequelae.

Treatment Options

The immediate goal in the treatment of a dislocated hip is to obtain concentric reduction as soon as practically possible. Generally, closed reduction should be attempted initially. Successful closed reduction can be achieved with intravenous or intramuscular sedation in the emergency room in many patients (49). Complete muscle relaxation is required for others, and this is best provided in the operating room with a general anesthetic. Open reduction is indicated if closed reduction is unsuccessful or incomplete.

Several methods of closed reduction have been described. Stimson described a maneuver for reduction of posterior dislocation of the hip. It is also referred to as the gravity method of Stimson. In this method, the patient is placed prone with the lower limbs hanging over the edge of a table. Two persons are required to perform this maneuver. An assistant stabilizes the pelvis by applying pressure downward from above. The manipulator holds the affected knee and hip flexed 90 degrees and applies gentle downward pressure in an attempt to bring the posteriorly dislocated head over the posterior rim of the acetabulum and back into the socket. Gentle internal and external rotation may assist in the reduction.

Allis described a maneuver in which the patient is placed supine and the reducing surgeon stands above the patient. For this reason, either the patient must be placed on the floor or the surgeon must climb onto the operating table. The knee is flexed to relax the hamstrings. While an assistant stabilizes the pelvis, the surgeon applies longitudinal traction along the axis of the femur and gently manipulates the femoral head over the rim of the acetabulum and back into the socket.

Bigelow described a manipulative reduction in which the patient lies supine and an assistant provides downward pressure on the pelvis. The surgeon grasps the ipsilateral limb at the ankle with one hand, puts the opposite forearm behind the knee, and applies longitudinal traction in the axis of the femur. Internal rotation, adduction, and flexion of 90 degrees or more take the tension off the *Y* ligament and allow the surgeon to bring the femoral head to the level of the acetabulum, posteriorly. The femoral head is then levered into the acetabulum by abducting, externally rotating, and extending the hip. This is a more forceful maneuver than the others and may cause damage to the articular surfaces of hip or even fracture the femoral neck, so it should be used with great caution.

A technique called the reverse Bigelow maneuver can be used for anterior dislocation. In this technique, the hip is held in partial flexion and abduction. One of two reduction methods may be used. The first is a lifting method in which a firm jerk is applied to the thigh, which may result in reduction. If that fails, traction is applied in the line of the thigh and the hip is then sharply internally rotated, adducted, and extended. This manipulative method may result in reduction but also risks fracture of the femoral neck.

With any type of dislocation, traction along the axis of the thigh coupled with gentle manipulation of the hip often effects reduction after satisfactory relaxation of the surrounding muscles.

If satisfactory closed reduction cannot be obtained using reasonable measures, it is appropriate to proceed with open reduction to remove any obstructing soft tissues.

Surgical Procedures

Open reduction of a posterior dislocation should be performed through a posterolateral approach. The patient is positioned in the lateral decubitus position with the dislocated side upward. The incision is centered on and just posterior to the greater trochanter and goes up into the buttock. Generally a straight incision can be made with the hip flexed approximately 90 degrees. Once the gluteal fascia lata is incised, the femoral head can be palpated beneath or within the substance of the gluteus maximus muscle. The fibers of the gluteus maximus can then be divided by blunt dissection, exposing the femoral head. The path of dislocation is followed through the short external rotator muscles and capsule down to the acetabulum. The sciatic nerve lies on the short external rotators and should be inspected. It may be necessary to detach the short external rotators in order to see inside the joint capsule.

Anterior dislocations should be approached through an anterior approach. This can be done through a bikini incision that uses the interval between sartorius and tensor fascia lata. The deep dissection follows the defect created by the femoral head down to the level of the acetabulum.

At the time of open reduction, the femoral head should be inspected for damage, scuffing, or fracturing. Before reduction, the acetabulum should be inspected and palpated for similar damage. Any intraarticular fragments should be removed. The labrum and capsule should be inspected for repairable tears. Labral fragments that cannot be securely replaced should be excised, but repair should be attempted. Frequently, the labrum or hip capsule is entrapped in the joint. The femoral head should be dislocated and any interposed soft tissue extracted. The labrum or capsule may be tied for ease in removal. Obstacles to reduction should be teased out of the way and the traumatic defect enlarged if necessary. The hip joint is then reduced under direct vision. Radiographs should be taken to confirm concentric reduction. If the joint appears slightly widened, repeat investigation must rule out interposed tissue. Slight widening may be due to fluid in the hip joint and this should settle out over the next few days. The capsule is repaired if possible. Closure is routine.

Open fractures should be treated with immediate irrigation and debridement. The surgical incision should incorporate and enlarge the traumatic wound. Inspection should proceed as detailed above. Capsular repair should be attempted if the hip joint is not contaminated. The wound should be left open or should be well drained to prevent invasive infection. As in all open fractures, intravenous antibiotics should be administered and repeat wound care performed as needed.

Postreduction Care

After reduction, treatment should be symptomatic. Generally a short period of recumbency, until the pain subsides, can be followed by return to ambulation with crutches if necessary. Bed rest, spica casting, skin traction, and non–weight bearing have not been proven to be beneficial (43,50,51). After open reduction with substantial capsulorrhaphy, immobilization or a spica cast may be indicated for a period of 6 weeks to allow capsular healing. Physical therapy is not routinely necessary. Return to full activities is encouraged.

Complications

Most hip dislocations in children will be treated and resolved without sequelae. Complications are rare.

Vascular Injury

Impingement on the femoral neurovascular bundle has been described after anterior hip dislocation in children, and this may occur in 25% of patients (50). If there is femoral artery occlusion, the hip should be relocated as soon as possible to remove the offending pressure from the femoral vessels. If relocation of the hip fails to restore perfusion, immediate exploration of the femoral vessels by a vascular surgeon is indicated.

Nerve Injury

The sciatic nerve may be damaged after a posterior dislocation of the hip in 2% to 13% of patients (35,50,51). Usually the nerve is directly compressed by the femoral head. The treatment is expedient relocation of the hip. Nerve function returns spontaneously in most patients (35,43). The nerve does not need to be explored unless open reduction is required for other reasons. If sciatic nerve function is demonstrated to be intact and is lost during the reduction maneuver, the nerve should be explored to ensure that it has not displaced into the joint. Other nerves around the hip joint rarely are injured at dislocation. Treatment is generally expectant unless laceration or incarceration is suspected. If so, exploration is indicated.

Avascular Necrosis

Avascular necrosis occurs in about 10% of hip dislocations in children (40,50). Prompt relocation of the hip, especially within 24 hours, may decrease the incidence of this complication (37,50). The risk of AVN is probably related to the severity of initial trauma (50). The cause is unknown. It may result from damage to ascending vessels or increased intracapsular pressure (49). The type of postreduction care has not been shown to influence the rate of AVN.

Early technetium bone scanning detects AVN as an area of decreased uptake. This is best seen on pinhole collimated images. After a few weeks, with the onset of revascularization and reossification, the uptake may appear normal or even increased.

Magnetic resonance imaging detects avascularity of the capital femoral epiphysis as loss of signal on T1-weighted images (48). Findings on T2-weighted images are abnormal but of variable signal intensity.

After hip dislocation, routine screening for AVN by bone scan or MRI cannot be strongly recommended for several reasons. Even if a perfusion defect is detected, there is no known treatment that will reverse it. Secondly, MRI may be falsely negative if performed within a few days of injury (48). Furthermore, hips with abnormal bone scan and MRI weeks after injury may not develop symptomatic AVN. In fact, a large proportion of perfusion defects seen on MRI spontaneously resolve after several months (41,48).

If hips are followed by serial radiographs for AVN, it is recommended that they be studied for at least 2 years after dislocation because radiographic changes may appear late (32). If MRI yields normal findings 4 to 6 weeks after injury, no further study is necessary because the risk of developing symptomatic AVN is miniscule (48).

If AVN develops, pain, loss of motion, and deformity of the femoral head are likely (31). AVN in a young child resembles Perthes' disease and may be treated like Perthes' disease (31). Priorities are to maintain mobility and containment of the femoral head to maximize congruity after resolution. AVN in older children should be treated as in adults and may require hip fusion, osteotomy, or reconstruction, as discussed following femoral neck fractures.

Recurrent Dislocation

Recurrence after traumatic hip dislocation is rare but occurs most frequently after posterior dislocation in children under 8 years of age (33,38) or in children with known hyperlaxity (Down's syndrome, Ehlers-Danlos disease). The incidence is estimated at no more than 3% (46). At surgical exploration of these hips, recurrence has been found to result from either laxity or a defect in the capsule (33). Recurrence can be quite disabling and in the long term may result in damage to the articular surfaces due to scuffing. Arthrography is recommended to identify a capsular defect or redundancy (33). Prolonged spica casting (at least 3 months) may stop recurrence (53), but exploration with capsulorrhaphy is a more rapid and reliable solution (33,38,53). In older children, recurrent dislocation can occur as a result of a bony defect in the posterior rim of the acetabulum similar to that in adults and may require posterior acetabular reconstruction.

Chondrolysis

Chondrolysis has been reported after hip dislocation in up to 6% of children (40,43,45,46) and probably occurs as a result of articular damage at the time of dislocation. Chondrolysis cannot be reversed by medical means, and treatment should be symptomatic. Antiinflammatory medicines and weight-relieving devices should be used as needed. If the joint fails to reconstitute, fusion or reconstruction should be considered.

Coxa Magna

Coxa magna occasionally occurs after hip dislocation. The reported incidence ranges from 0% to 47% (40,45,46). It is believed to occur as a result of posttraumatic