SURGICAL ANATOMY
The hip joint is a rather complex ball and socket joint encompassed by the pelvis and the femur. (19) The proximal end of the femur has a nearly hemispherical head, which is used for articulation of the joint. This head is connected to the shaft by a short, thick neck. The greater trochanter projects above the top of the femur, and a lesser trochanter is present on the medial aspect of the femur below the femoral neck. The trochanteric fossa is located between the femoral neck and the greater trochanter caudal to the ridge of bone connecting the two. The acetabulum represents the concave portion of the coxofemoral joint and is made up of the junction of the ilium and ischium. There is a large central acetabular fossa that is surrounded by the articular lunate surface of the acetabulum. This deep acetabulum is further extended by the band of fibrocartilage surrounding its rim. This acetabular lip is continued as a transverse acetabular ligament in the ventral aspect of the femur and completes the circular restraint of the hip joint. The ligament of the head of the femur, also known as the teres ligament or round ligament, is a short, flat ligament that connects the center of the femoral head to the acetabular fossa. This ligament contributes to femoral stability by retaining the femoral head within the acetabulum and in the adult dog provides some vascularity to the femoral head. The coxofemoral joint is surrounded by a thin, fibrous joint capsule that is connected to the femur at the base of the neck and at the acetabulum just around the acetabular lip.

Stability of the hip joint is further increased by the muscles that attach the proximal femur to the pelvis. These muscles are grouped according to function; the gluteal muscles (superficial, middle, deep, and piriformis) are responsible for abduction and internal rotation of the hip joint; the external rotator group of muscles (internal and external obturator, gemellus, quadratus femoris) are responsible mostly for external rotation of the hip joint along with the iliopsoas, which attaches to the lesser trochanter and, along with the tensor fasciae latae muscle, also causes hip flexion. Adduction function of the hip joint is accomplished through muscles that attach with the pelvis further down the shaft of the femur, such as the adductor and pectineus group.

The vascular supply to the hip joint seems to change with the age of the dog. (1,12,25) Initially, the great preponderance of vascular supply appears to be from branches of the femoral and deep femoral arteries. The lateral circumflex femoral artery rises from the femoral or deep femoral artery and provides most of the arterial supply to the capital femoral epiphysis and dorsal aspect of the femoral neck, with the medial circumflex artery arising from the femoral or deep femoral artery to supply the medial aspect of the joint capsule near its femoral attachment ventrally. The caudal portion of the femoral head is supplied through an anastomosis of the medial and lateral circumflex femoral arteries. A small branch of the caudal gluteal artery supplies the joint capsule on the dorsal aspect of the femoral head as well. In the puppy with open physes, the femoral head is supplied mostly by the rich vascular supply ventrally through the inferior retinacular vessels, which branch from the medial circumflex femoral artery.(1) In the adult dog with closed epiphyseal plates, it appears that nutrient supply to the femoral head may be in part through the ligament of the head of the femur as well as through penetration of the epiphysis by vessels that originate from the nutrient artery of the femur. (12) The more precarious vascular supply of the young animal should be kept in mind when dealing with injuries of the hip and planning surgical approaches.
Surgical Approaches to the Hip
Four basic approaches to the canine hip joint are in common use.(16) Minor modifications of each type of approach may be chosen for specific indications and personal preference.

Cranial Approach
The cranial approach (modified Watson-Jones(24)) exposes the femoral head cranial to the greater trochanter. The skin incision is made either as a caudal flap over the greater trochanter or as a relatively straight or slightly curved incision cranial to the greater trochanter. Following opening of the skin, the biceps muscle is retracted caudally and the fascia of the tensor fascia lata muscle is incised with the axis of the femur. Retraction of the tensor fascia lata muscle cranially will reveal a small triangular portion that is made from the vastus lateralis caudally and the gluteal muscle dorsally. Retraction and blunt dissection through the apex of this triangle will reveal the articularis coxae muscle sitting overtop of the acetabulum. The incision into the acetabulum can be made through the joint capsule either parallel to the neck of the femur or parallel to the rim of the acetabulum. Whichever method is chosen, care should be taken that the joint capsule can be closed following the surgical procedure to help provide stability to the hip joint. Care also must be taken in this approach to avoid damaging the lateral circumflex femoral artery, which can be retracted distally.

Dorsal Approach
Two dorsal approaches have been described in the literature. The dorsal approach of Brown can use a variable skin incision as described above or a saucer-shaped incision just below the greater trochanter.(3) In this procedure, after separation of the biceps muscle, the gluteal muscles are sectioned close to their insertion on the greater trochanter of the femur in order to provide exposure to the hip joint. The same exposure to the dorsal aspect of the joint is achieved with the approach of Gorman except that the middle and deep gluteal muscles are not separated through their tendon insertions as in the Brown approach, but a trochanteric osteotomy is performed, which will allow retraction of the middle and deep gluteal muscles still attached to their bony insertion.(13) This brings the exposure down to the joint capsule, which again can be incised to open the joint. Closure of the wound in this case requires reattachment of the greater trochanter at the osteotomy site. Small Kirschner wires or a tension band device can be used for the reattachment of the greater trochanter. In some cases, the greater trochanter may be attached in an abnormal position to achieve desired changes of force on the hip joint.(8)

Caudal Approach
The caudal approach to the hip joint involves a skin incision similar to that of the cranial approach, but the skin incision is placed over the caudal aspect of the greater trochanter instead of cranial to it. Following retraction of the biceps muscle, the sciatic nerve is identified and the external rotator muscles are seen. These external rotators are sectioned close to their origin on the femur and retracted to provide exposure of the caudal joint capsule.(16)

Ventral Approach
A ventral approach to the hip joint is made with the dog on its back with the legs widely abducted.(7) The skin incision is made over the pectineus muscle. The pectineus muscle is separated bluntly from the surrounding tissue and transected over the acetabulum. This increases the abduction of the limb and allows further dissection to proceed. Retraction of the abductor and gracilis muscles caudally and the femoral artery and vein cranially exposes the iliopsoas muscle and deep femoral artery and vein on its surface. The obturator nerve in the abductor muscle can be retracted, and the iliopsoas muscle with the deep femoral artery and vein can be reflected laterally to expose the joint capsule. The capsule is incised parallel to the midline and reflected to expose the femoral head, ligament of the head, and ventral acetabulum.(16)

Fractures of the Hip Joint
Fractures of the hip include those of the proximal femur and those through the pelvis and acetabulum. Acetabular fractures are included with pelvic fractures. (See Chapter 27.) Fractures of the proximal femur include fractures of the femoral head and neck and the proximal femur.

Fractures of the proximal femur may be classified as follows: intracapsular fractures, such as fractures of the epiphysis, fractures through the physis, and proximal neck fractures; or extracapsular fractures, which include base neck fractures and
fractures distal to the attachment of the joint capsule. Fractures below the distal attachment of the joint capsule are classified as intertrochanteric fractures if they occur between the greater and lesser trochanters, pertrochanteric fractures if they include the greater trochanter, and subtrochanteric fractures if they are below the lesser trochanter. The diagnosis of proximal femur fracture can usually be made based on physical examination. The exact characterization of the fracture necessary for adequate treatment must be made using biplane radiography. Single radiographic views may offer an inadequate diagnosis. Comminution or fracture fragment separation can easily be overlooked when taking only a single view. The two views recommended include a ventral-dorsal radiograph with the hind legs extended symmetrically (normal hip dysplasia radiograph) as well as a lateral view, with complete abduction of the upper uninjured extremity out of the field. In comparison with other fracture groups, fractures of the femoral head and neck in the dog and cat are rather well represented in the literature (2,9,17,20,23).

FRACTURES OF THE FEMORAL HEAD AND NECK
Fractures of the femoral head and neck are a condition of the young dog. Most dogs that are older than 10 to 12 months of age will have a coxofemoral dislocation rather than a femoral head or neck fracture. Base neck fractures occur in some older dogs but are uncommon. Most fractures are the result of vehicular trauma, with the fractures occurring perpendicular to the long axis of the neck of the femur. Shearing-type fractures that result from falls are rare, but when they occur are associated with fracture lines that are parallel to the axis of weight bearing. Fractures through the physeal line of the femoral head are the most commonly occurring fracture in this group. According to Daily, (3) neck fractures seem to be about evenly divided between intracapsular and extracapsular fractures. Although the base neck fractures would appear to be the most easily repaired fracture, they are often difficult to reduce, and the long-term clinical results seem to be poorer than those of physeal fractures. Treatment regimes for femoral head and neck fractures range from external support, which usually leads to a poor outcome with resorption of the femoral neck (Figs. 28-1 and 28-2), to internal fixation either with multiple pins (6) or single screw fixation. Interfragmentary screw fixation seems to be an ideal form of fixation for femoral neck fractures in the dog and cat. Although the procedure is technically demanding, the results are surprisingly good. If the technical aspects of surgery are followed and the reduction is adequate, fracture healing follows almost invariably, and aseptic necrosis of the femoral head does not represent a significant problem in the dog. The time interval from fracture to treatment is important in preventing resorption of the femoral neck. If left alone, most femoral head and neck fractures will go on to a fibrous nonunion with resorption of the femoral neck and a painful end result. A lack of resorption of the femoral head may, in fact, be due to its lack of blood supply,(12) since vascularization is necessary for bone resorption (Figs. 28-1 and 28-2). It has been reported that the femoral head will remain alive at least 3 weeks following fracture in the adult dog as shown through tetracycline-labeling techniques. Revascularization of the head takes place following adequate reduction and stabilization using interfragmentary compression. Large resorption cavities do not appear in the femoral head, and collapse is not associated with femoral neck fractures as it is with Legg-Calve-Perthes disease (Fig. 28-3).

Surgical treatment of femoral head and neck fractures should be carried out as soon as the patient's condition allows it. The surgical approach is a cranial one, which is chosen to preserve as much as possible the vascularity to the joint capsule and femoral head. The inferior retinacular vessels are undisturbed. The dorsal approach has two major drawbacks: (1) Osteotomy of the greater trochanter will destroy any blood supply that enters the femoral neck via the gluteal muscle mass, as well as the lateral circumflex vessel, which enters dorsally; myotomy will have the same effect. (2) Since femoral neck fractures occur in young dogs with open physes, osteotomy of the greater trochanter may, in a young dog, lead to premature closure of that
physysis with resulting valgus deformity of the femoral head and neck. Experimentally it has been shown in a number of animals that closure of the physys of the femoral head will induce a varus hip deformity, while closure of the greater trochanter epiphysis will induce a valgus hip deformity(5,18,22) Although closure of the proximal femoral epiphysis seems not to be significant clinically, since varus deformity may help increase the stability of the hip joint, closure of the greater trochanter can produce a valgus deformity in the dog, leading to subluxation and instability. One experimental study in the chondrodystrophoid dwarf (beagle) concluded that no damage occurred when trochanteric osteotomies of the greater trochanter of the femur were performed.(15) Clinical experience in other breeds, however, warrants the use of the anterior approach to the femur in a young dog with an open physysis of the greater trochanter.

A cranially curved skin incision is made starting just above the greater trochanter and around the greater trochanter distally to the proximal one-quarter of the femur. The fascia of the tensor fasciae latae is divided close to the muscle fibers, and the biceps femoris is retracted caudally. The rest of the dissection is done bluntly with the retraction of the gluteal muscles dorsally, the rectus femoris and tensor fasciae latae cranially, and distal retraction of the lateral circumflex femoral artery. This opens a small window to the acetabular rim and joint capsule. When the joint capsule is intact and the fracture is intracapsular (physeal fracture or proximal neck fracture), the joint capsule is incised perpendicularly to the line of the acetabular rim, allowing visualization of the fracture site but destroying very little blood supply. When the fracture is extracapsular, the capsule is usually opened in the same manner to ensure correct positioning of the capital fragment. If visualization of the fracture site is inadequate, the exposure can be enlarged by minimally cutting the cranial part of the gluteal muscles near their insertion and providing additional retraction.

The fracture is stabilized with an interfragmentary compression technique.(20) The technique involves the drilling of a large gliding hole through the proximal femur and a small threaded hole into the neck or head of the femur. It is usually easier to drill the large gliding hole before reduction of the fragment, so that this hole can be centered precisely in the femoral neck. Following the drilling of this clearance hole, the fracture is reduced and stabilized initially with a small Kirschner wire. Reduction is checked and range of motion carried out minimally to ensure that the reduction is adequate. Accurate reduction is the most difficult portion of the surgical procedure and must be accomplished to ensure a good result. Following reduction, the drill insert is inserted through the large gliding hole and the small threaded hole is drilled into the femoral head. The hole is measured, tapped, and a fully threaded cortical screw is used for fixation. It is not necessary to countersink this screw, since the screwhead will pull itself into the soft bone of the upper femur very nicely (Fig. 28-4). In fact, a cortical screw that is approximately 2 mm shorter than the hole that was measured is usually chosen. Accurate adjustment of length can be made by using a washer when necessary (Fig. 28-5). In this way the threads will catch the proximal fragment but not protrude into the joint. Following the tightening of the screw, the Kirschner wires are removed and the joint is checked for crepitation. Full range of motion should be carried out at this time to ensure that the screw has not penetrated the joint space. It is usually not necessary to add an extra pin to guard against rotation, since these fractures are very close to the joint surface and the small coefficient of friction in the joint will prevent rotational deformity if interfragmentary compression is used. The danger of
this technique is in using a partially threaded screw in which the gliding hole is not complete, thereby trapping the fragments apart and allowing rotation to occur. If this is a possibility, the insertion of an extra Kirschner wire to prevent rotation would be necessary for success of the procedure. In general, the large frictional forces generated by the interfragmentary screw are more than enough to overcome forces on the fracture that would cause rotational instability.

FIG. 28-5 A base neck fracture of the femur in a dog (A) was reduced and stabilized (B) with a lag screw technique. Since screw sizes come only in 2-mm increments, the use of a washer can adjust screw length for a perfect fit. This is more critical when dealing with capital epiphyseal fractures. (c) The healed fracture shows a varus deformity. No abnormal clinical signs are associated with a mild deformity such as this in the dog.

Postoperatively, the animals are not placed in any form of external bandage or splint and are usually weight bearing within 3 to 4 days. Complete restriction of the animal is suggested for a period of 6 weeks. Screws are not usually removed unless they cause a problem. The same approach can be used with three Kirschner wires or small Steinmann pins for fixation. If a retrograde insertion of the pins is performed, the exposure must be increased accordingly. Multiple pins are necessary to prevent rotation of the reduced fracture.(6)

FRACTURES OF THE FEMORAL NECK AND PHYSEAL FRACTURE OF THE GREATER TROCHANTER
The simultaneous fracture of the femoral neck or capital physis and the greater trochanter through the apophysis is not uncommon.(9,20) Radiographically, the femur appears to be riding very high, with the femoral head sitting in the acetabulum and an additional fragment, which is the greater trochanter, sitting lateral to it. The surgical approach is simple, since dissection has already been carried out by the injury. Because the greater trochanter has already been displaced, the approach starts out as an anterior approach but soon becomes a dorsal approach, and visualization of the fracture is very wide. Care must be taken in the repair of these fractures not to create a valgus deformity. The reduction of the fracture should either be perfect or in slight varus position (Fig. 28-6). The varus deformity will resolve itself within the time of fracture healing. With adequate reduction and stability good to excellent results are obtained in approximately 90% of the cases. The prognosis for fractures of the base of the neck of the femur seems to be slightly worse, but good results can be expected. Most of the poor results seem to be related to inadequate reduction or fixation at the time of surgery.

FIG. 28-6 (A) A femoral neck fracture associated with an apophyseal separation of the greater trochanter in a 6-month old Labrador. (B) The fractures have been fixed using a screw for interfragmentary compression (note the varus position) and Kirschner wires in the greater trochanter. (C) Resolution of the fracture shows a near normal femoral neck angle and full function.

Fractures of the hip joint respond well to internal fixation if the hip is stable. Adequate reduction with the head in normal or in varus position will invariably give a better result than if the fracture is reduced with the head in the valgus position. This is in contrast to the results that are seen in fractures of the hip in humans, in whom a valgus position of the femoral head is considered optimal. The differences between the two species are probably related to the posture the animal takes during weight bearing and the relative position of the pelvis and the femoral head. Aseptic necrosis is not usually a problem of
Femoral head and neck fractures in the dog if, in fact, surgery is carried out soon after the injury. Most of the vascular resorption of bone that occurs is in the femoral neck, with the femoral head itself remaining unchanged for at least 3 weeks following fracture. Adequate internal fixation ensures prompt use of the injured extremity with an expected good outcome.

Small chip fractures of the femoral head are very rare except in association with dislocations. If untreated, nonunion and degenerative joint disease may result. If the chip is from the non-weight-bearing ventral surface, removal is recommended. Surgical reduction and fixation, while possible, may be difficult and unnecessary. Fractures of the weight-bearing dorsal surface require femoral head and neck resection or total hip arthroplasty if the hip is unstable or subsequently develops degenerative joint disease.

PERTROCHANTERIC AND INTERTROCHANTERIC FRACTURES
Fractures through the trochanteric region in the dog are often associated with femoral head and neck fractures as well. Multiple fractures of the proximal femur or comminuted fractures are seen more commonly than are simple intertrochanteric fractures (Fig. 28-7). Reconstruction of such fractures involves saving the head and neck as well as stabilizing the rest of the fracture, which may include fractures of the shaft. My personal preference for stabilizing these types of fractures is to use lag screws for interfragmentary compression where possible and then regular plates or blade plates. Although the use of the ASIF child’s osteotomy plate is not widespread in veterinary orthopaedics, it is a very useful device that eliminates failure almost completely if applied correctly. (The technique of application is described in Chapter 43 on femoral osteotomy.) Sometimes longer side plates are needed and are available to control fractures of the shaft as well as fractures of the proximal femur. (See Fig. 28-7.) Complex bending of the proximal end of the normal plate may allow coaptation of the fragments such that screw fixation can be incorporated through the plate itself. The newer ASIF double-hook plate may also be used in these situations. Use of intramedullary pins combined with wire fixation has been tried with some success in the past but I do not recommend it. In reconstructing intertrochanteric, pertrochanteric, or comminuted pertrochanteric fractures, particular attention must be given to positioning of the femoral head and neck. Most of these fractures will resolve any varus deformity that is incorporated into the fixation, but a valgus deformity of the hip will tend only to increase, causing subluxation and osteoarthrosis. Therefore, it is of extreme importance to correctly reduce the femoral head and neck on the shaft of the femur to provide for a good long-term result.

FIG. 28-7 (A) A comminuted fracture of the proximal femur involving the femoral neck and trochanteric region with its transverse component subtrochanteric. (B) Radiograph demonstrates the fractures following reduction and stabilization with lag screws and a plate. (C) The 7-month postoperative film shows complete healing with some hip subluxation. Functional rating of the limb was excellent. (Nunamaker DM Repair of femoral head and neck fractures by interfragmentary compression. J Am Vet Med Assoc 102:569, 1973)

SUBTROCHANTERIC FRACTURES
Subtrochanteric fractures can be handled more easily with multiple pins and cerclage wires or with normal plating techniques incorporating screws through the proximal end of the plate, which enter the femoral neck and head. In this way, adequate fixation can be obtained in most instances in the dog. The use of simple intramedullary fixation for true subtrochanteric fractures usually results in rotational deformity or fracture instability leading to malunion or nonunion. A more complete discussion can be found in Chapter 29, Fractures of the Femur.

DISLOCATION OF THE HIP
Coxofemoral luxations occur in dogs and cats, usually over 10 months of age, that have been involved in some form of major trauma. The hip joint itself is a stable joint when not affected by disease (hip dysplasia). The luxation of a normal hip joint
will result in pain around the hip area and abstinence from weight bearing. The normal coxovalgus stance with slight external rotation of the leg is typical of anterior dorsal dislocation of the hip. The hip may dislocate in many directions. Ninety percent or more of dislocations are associated with the cranial dorsal direction. The femoral head slips over the dorsal rim of the acetabulum, coming to lie in the area of the origin of the deep gluteal musculature. For dislocation to occur, the joint capsule must tear as well as the ligament of the head of the femur. Subluxation can occur with an intact round ligament, but dislocation is possible only when there is rupture of the ligament. Although cranial dorsal luxations are most common, luxations may also occur cranial ventrally, ventrally, and caudally. Central dislocations are really fractures of the acetabulum that allow the femoral head to protrude into the pelvic lumen. Central dislocations of the femur are described in the chapter on pelvic fractures. Cranial dorsal dislocations of the femur occur when the leg undergoes adduction with external rotation of the hip following a longitudinal force on the long axis of the leg to drive the femur cranially and dorsally. Most cranial ventral dislocations are associated with cranial dorsal dislocations that have been reduced unsuccessfully into the cranial ventral position. Caudal dislocations are extremely rare, while ventral dislocations may represent the second most common form of naturally occurring dislocation. Very often the femoral head will be sitting in the obturator foramen, making the hip joint appear very stable, but on physical examination the greater trochanter is no longer palpated. Some of these dogs may walk on their legs with only moderate pain.

DIAGNOSIS
The diagnosis of hip luxation is made by assessing position of the hip and its range of motion. Leg length discrepancies are the most commonly used criteria for diagnosis of hip luxation. Symmetric extension of both hind legs may reveal that the injured leg is either longer (ventral dislocation) or shorter (cranial dorsal or cranial ventral dislocation) than the opposite limb. Placing the animal on its back and evaluating the height of the tibial crest when the femur is perpendicular to the table and the tibias are held parallel to the table will also be of help in determining the relative position of the hip joint (Allis sign). Careful palpation will reveal a change in the distance between the greater trochanter and the ischial tuberosity when comparing the normal and abnormal sides. The greater trochanter of the dog normally lies about two thirds of the way from the crest of the wing of the ilium to the ischial tuberosity, with the greater trochanter in line or below a line drawn from the dorsum of the crest of the ilium to the point of the ischial tuberosity. Palpation and range of motion excursions of the hip reveal that the hip is carried in external rotation and cannot be internally rotated when anterior dorsal dislocation is present. Internal rotation is slightly increased when the luxation is in the anterior ventral position, but in both adduction is very limited. Ventral luxation, on the other hand, allows good internal rotation and may on occasion seem to have a good range of motion, but the leg will appear longer when the animal is checked for the Allis sign. The greater trochanter appears to be absent on palpation because of its ventral medial position.

Caudal luxation may cause significant injury to the sciatic nerve as it passes behind the acetabulum and appears over the sciatic notch of the ischium. Luckily, caudal dislocations are rare, but when they occur, open reduction should be considered from the start to avoid doing further damage to the sciatic nerve through closed manipulative reduction. Some luxations involve such distractive force that the hip can be placed in any position at any time. This type of dislocation does not give good results following any form of relocation.

TREATMENT
CLOSED REDUCTION
Following diagnosis, closed reduction of hip luxation can be carried out. Reductions are easier to perform immediately following injury and should be done at this time if the patient's condition allows it. Closed reduction can be accomplished successfully until approximately 10 days following the injury. Occasionally, positive results can be achieved up to 3 weeks, but usually open reduction would be necessary to remove the organizing hematoma and debris in the acetabulum at this time. It is wise not to spend a long time doing closed manipulation maneuvers without obtaining a reduction, since considerable damage can be sustained by the femoral head and surrounding soft tissues. If success is not achieved readily, open reduction should be considered.

Closed manipulation should be done only under general anesthesia. A short-acting thiobarbiturate is usually adequate. Heavy sedation is not efficacious, since it does not allow complete relaxation. Muscle relaxants are not necessary.

Closed reduction of a cranial dorsal luxation is accomplished most easily with manipulation of the limb using a modified Schroeder-Thomas splint as an extension brace between the dog's groin and the manipulator's waist. The relocation can be
made without assistance using this device. The modified Schroeder-Thomas splint used in this technique is placed under the leg and slid up to the groin. The leg is positioned so that when pulling on it the femoral head will be pulled over the acetabulum. In most instances, this means that the leg is pulled more caudally than ventrally. The initial reduction is accomplished by first loosening the hip joint in its abnormal position to allow more motion of the hip joint to stretch the involved muscles that are in spasm. The leg is then extended, adducted, and externally rotated. Further traction will draw the femoral head over the acetabular rim so that abduction and internal rotation will result in reduction of the hip. Placement of one hand over the greater trochanter while the opposite hand is holding the leg can facilitate this manipulation. There is generally a resounding sound of reduction and the hip joint is then checked for range of motion, keeping it in abduction. The leg is usually held in an Ehmer sling to provide shortening of the lever arm, internal rotation of the femoral head, and abduction of the hip. This drives the femoral head into the acetabulum in its deepest aspect. Following reduction, the Ehmer sling is usually left in place for approximately 10 days and then removed. In some dogs, additional abduction can be obtained by spiraling tape around the body of the animal and then connecting it to the hock joint.

Most cranial dorsal dislocations of the hip joint can be reduced in a closed manner and stabilized as described. The literature shows a success rate that ranges from 28% to 82% for this mode of treatment. The causes of failure of closed reduction are usually associated with fracture fragments of the femoral head or acetabulum, such as may occur with dorsal rim fractures of the acetabulum, avulsion fractures of the femoral head associated with the round ligament, or soft tissue positioned between the femoral head and acetabulum as often occurs during hip reduction. When the joint capsule becomes interposed between the head of the femur and the acetabulum, a very slippery surface is generated from contact of the synovial surface of the joint capsule on to the acetabular surface, and it is difficult to hold the head in position. Other reasons for failure of closed manipulation are related to abnormal hip development (hip dysplasia) and osteoarthritis. Any flattened acetabulum, flattened head, or associated osteoarthrosis of the hip joint can lead to an unstable hip. Only minimal trauma may be necessary to dislocate such a hip, and repair through closed reduction may be impossible.

OPEN REDUCTION
The literature contains many open reduction procedures for reducing and stabilizing hip luxations. Some hip dislocations can be reduced only through open reduction. Other luxations that can be reduced often need additional stability, which can be achieved through one of the open reduction techniques with a concurrent stabilization procedure. The majority of cranial dorsal dislocations of the hip involving normal acetabula and femoral heads that are treated through open reduction

FIG. 28-8 A cranial-dorsal dislocation is seen, with a small fragment of bone sitting in the acetabulum. This avulsion fracture of the femoral head insertion of the round ligament must be removed before reduction is accomplished.

FIG. 28-9 Cranial-caudal radiograph demonstrates a chip fracture of the dorsal rim of the acetabulum associated with a cranial dorsal hip dislocation.
can be dealt with adequately by closing the joint capsule, if present, with simple interrupted sutures and placing the animal in an Ehmer sling following surgery. With this procedure, a cranial approach is made to the hip joint and the acetabulum is debrided. Following reduction of the hip, the joint capsule is sewn together and the wound closed routinely. Sometimes the joint capsule may not be present, such as after a prolonged luxation in which the joint capsule has been worn away. In these cases, other forms of internal fixation or stabilization must be used to provide fixation. The techniques used for hip stabilization include, but are not limited to, the following:

REPOSITIONING OF THE GREATER TROCHANTER OF THE FEMUR IN A DISTAL CAUDAL DIRECTION to provide abduction and internal rotation of the femur(8) is combined with the dorsal approach of Gorman, which involves trochanteric osteotomy. Following reduction of the hip joint, the greater trochanter is repositioned at the osteotomy site in a position more distal and more caudal than normal. Attaching the greater trochanter with wires and pins will stabilize this new position until healing occurs. The animal is usually placed in an external Ehmer sling following this procedure to help stabilize the hip joint initially. The repositioning of the greater trochanter is probably helpful only in the early phases of recovery, and the muscle will realign itself so that there is no long-term gait abnormality.

KNOWLES TOGGLE PINNING
Re-creation of a round ligament or ligament of the head of the femur has been advocated periodically since the mid 1950s. (17a,21) The technique seems to be more popular in Europe than in the United States but has been advocated for maintaining reduction of femoral heads in dogs with unstable hips. The technique involves creating a tunnel through the head and neck of the femur, which exits at the level of the fossa fovea of the ligament of the head of the femur. After drilling this hole, the head is repositioned in the acetabulum and a hole is extended through the acetabulum while the femur is held in a neutral position. The toggle device is then introduced through this hole and attached to the greater trochanter with a wire or suture material. The advantage of this procedure is that the hip is inherently stable immediately following surgery and the animal can be weight bearing within several days. Some authors restrict activity with the use of an Ehmer sling, but this does not seem to be necessary. The disadvantage of the procedure is that the new ligament will break in time because of fatigue of the material. If this occurs after the hip is already stabilized, a good functional result will prevail. If the ligament ruptures before this occurs, dislocation can recur.

DEVITA PINNING
The DeVita pin was designed as a method for stabilizing chronic luxations of the hip.(10) The technique involves insertion of a Steinmann pin, usually with a threaded tip, underneath the attachment of the hamstring muscles at the ischium, through and overtop of the external rotators and sciatic nerve, over the neck of the femur, and into the wing of the ilium. The technique should not be performed as a closed procedure (although it frequently is) without observation of the sciatic nerve, since piercing the sciatic nerve may be an unhappy sequela of this procedure. The other most common problem associated with this procedure is migration of the pin. The pin often migrates along the epaxial musculature of the back and has been known to penetrate the brain and the heart. In light of its possible sequela, the added stability that this procedure gives, does not, in my opinion, warrant its use. DeVita pinning is a technique that is no longer used at the Veterinary Hospital of the University of Pennsylvania (VHUP).

FEMORAL HEAD AND NECK EXCISION
Many other techniques described in the literature are not included here because I have had little or no experience with them. Most hip luxations can be treated using any one of the techniques advocated above and the outcome will be satisfactory. Only occasionally will femoral head and neck excisions be necessary for the relief of pain associated with nonreduced luxations. In my experience, the results of femoral head and neck excisions are preferable to those of leaving the joints unreduced. Excision arthroplasty, when carried out in dogs under 40 pounds, will usually give a satisfactory result. The removal of the femoral head and neck can be accomplished through any of the surgical approaches to the hip joint. The ventral approach should not be used, however, when the hip is in a cranial dorsal luxation position, since it cannot be reached adequately. I prefer the cranial approach for dissection of the femoral head and neck. An osteotomy is made through the base of the femoral neck using either a Gigli wire or an osteotome. Following removal of the head and neck, care is taken to make sure that the osteotomy surface of the bone is smooth, especially in the ventral aspect. Closure of the joint capsule does not seem to be necessary, since the proximal femur will glide above the dorsal rim of the acetabulum. The only time closure of the joint capsule would be deemed necessary would be in central dislocations of the femur in which the femoral neck has a good
chance of adhering to the fractures of the pelvis. Following closure of the wound, the animals are usually restricted in activity until the sutures are removed at 10 to 14 days, at which time exercise is encouraged. Results of femoral head and neck excision are such that the animals may continue to improve up to one year following surgery. The successful outcome of a femoral head and neck excision allows the animal to use the limb in a relatively pain-free manner although there may remain some limp or gait deficit. Femoral head and neck excision seems to be necessary only after repeated attempts at closed and open reduction have failed or initially when there is an unstable acetabulum or femoral head component associated with hip dysplasia or osteoarthritis.

REFERENCES


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