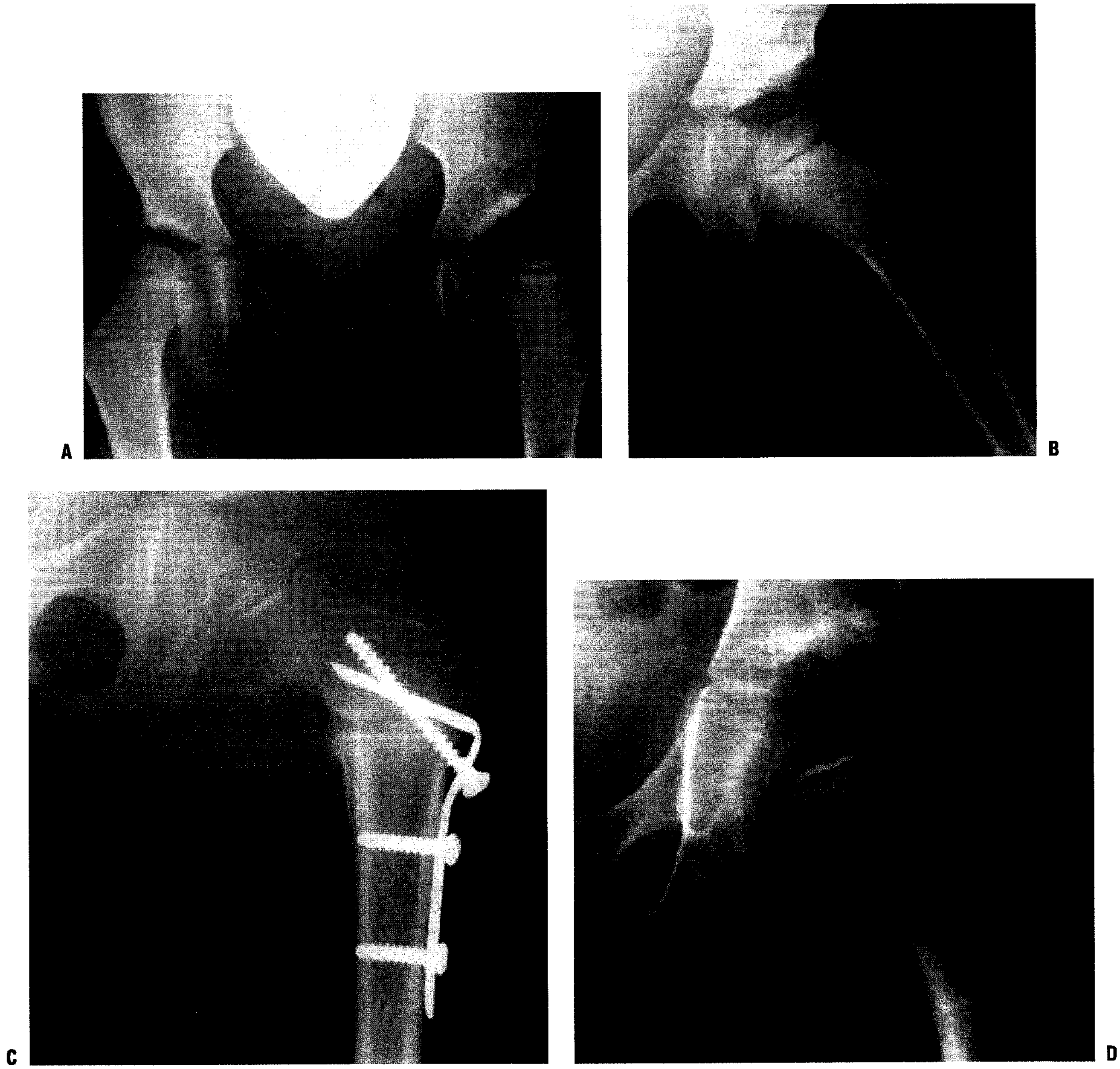

FIGURE 23-58. A 3-year-old girl 2 years after closed reduction. **A**: Anteroposterior view of the pelvis. Note the persistent acetabular dysplasia and apparent coxa valga. **B**: The radiograph shows the leg abducted approximately 30 degrees and maximally internally rotated. The femoral head is seated well within the acetabulum, and the Shenton line is restored. **C**: Anteroposterior view of the left hip 6 weeks after varus derotation osteotomy. **D**: Anteroposterior view of the left hip 18 months after varus derotation osteotomy, with hardware removed. The Shenton line has been restored; persistent acetabular dysplasia remains, but development of the teardrop figure improved, and accessory centers of ossification have appeared in the periphery of the acetabular cartilage.

actual angle of the femoral neck. If concentric reduction is not documented, this procedure should be accompanied by open reduction.

Intertrochanteric osteotomy is probably the most common operation performed around the child's hip. It is used for a variety of conditions. In hip dysplasia, intertrochanteric osteotomy may be simply a derotation osteotomy or a derotation osteotomy combined with femoral shortening or a combination of the above adding varization to the procedure. As preoperative planning is essential, a more detailed description of this particular procedure follows.

As mentioned above, an intertrochanteric osteotomy can have one or several components. Among these are varus, valgus, extension, flexion, rotation, shortening, medialization, lateralization, and transfer of the trochanter. The indications for each of these components are found in a careful analysis of the physical examination and the preoperative radiographs. Altering the varus inclination of the femoral neck will have profound effects on the abductor lever arm as well as on the forces across the knee joint. Thus, in a particular circumstance, a varus osteotomy may require both greater trochanter transfer, to restore the articulotrochanteric distance, and medialization of the femoral shaft, to maintain an equal weight distribution through the medial and lateral compartments of the knee. For most of the intertrochanteric osteotomies in children in which the remainder of the limb is in normal alignment, it is usually sufficient to account for the following relations in planning:

- Varus osteotomy results in genu varum and requires medial displacement of the femoral shaft to restore normal alignment to the leg.
- Valgus osteotomy results in genu valgum and requires lateral displacement of the femoral shaft to restore normal alignment to the leg.

A varus intertrochanteric osteotomy in the normal hip of >25 degrees may need trochanteric transfer to maintain normal abductor muscle function. If a varus intertrochanteric osteotomy is performed in a hip with an already decreased articulotrochanteric distance, with a proximal physeal growth arrest as frequently seen in Perthes disease, or in conjunction with a medial displacement pelvic osteotomy (e.g., a Chiari osteotomy), the need for transfer of the greater trochanter is increased.

A valgus intertrochanteric osteotomy lengthens the leg and increases the pressure on the femoral head (just as a varus osteotomy shortens the leg). Release of tight muscles or shortening of the bone should be considered (Figs. 23-59 to 23-64).

Preoperative Planning. Preoperative planning in the detail described here is not usually necessary for an intertrochanteric varus osteotomy in a 2-year-old child undergoing reduction of a congenitally dislocated hip. It is essential for intertrochanteric osteotomies in the older child, however, because the mechanical effects are greater, the potential for remodeling is less, and derangements are more complex.

After reviewing the clinical aspects of the condition, planning begins with a preoperative anteroposterior view of the pelvis and both hips. The normal hip radiograph should be taken in internal rotation to see the normal neck shaft angle. If there are other mechanical alterations in the alignment of the limb, a full-length radiograph from the hips to the ankles with the patient standing should be obtained on a 36-inch cassette. This permits the surgeon to examine the effect of the intertrochanteric osteotomy on the alignment of the limb and the need for additional osteotomies. Depending on the circumstances, additional radiographs with the limb in various positions can be obtained to determine the range of motion of the femoral head in the acetabulum and the best position for congruity. In some difficult cases, this is done with an arthrogram. In our opinion, the degree of anteversion is best determined functionally by the rotation of the hip in extension rather than by radiographic means because the surgeon may be misled into correcting the radiographically determined amount of rotation only to find that the hip will not have sufficient internal rotation postoperatively. If one would like to do a proximal femoral osteotomy using a 90-degree blade plate, a somewhat different technique would be used (Figs. 23-65 to 23-74).

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Planning an Intertrochanteric Osteotomy (Figs. 23-59 to 23-64)

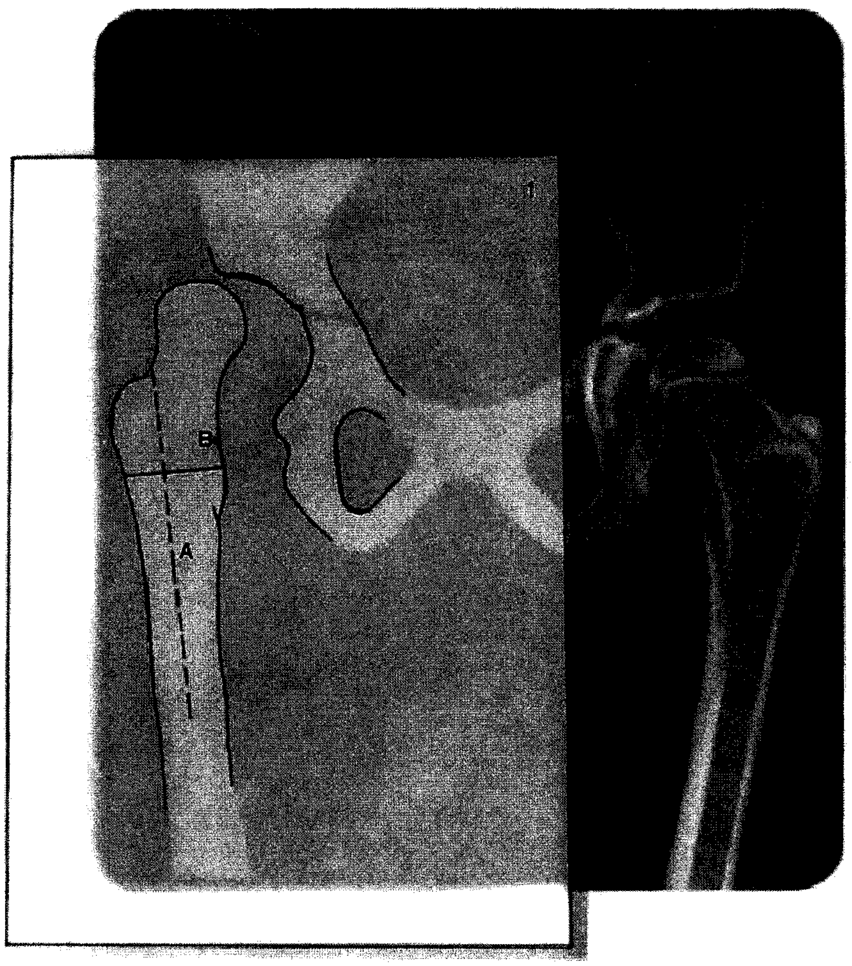


FIGURE 23-59. Planning an Intertrochanteric Osteotomy. The actual process of planning the osteotomy has been well described by Muller (1975). This can be done on transparent paper or radiographic film. Two drawings are made on two separate sheets of paper or film. This first drawing traces the exact outline of the femoral head and the proximal shaft and the acetabulum. A *dotted line* (A) is drawn down the axis of the femoral shaft and a second *solid line* (B) is drawn perpendicular to the dotted line just above the lesser trochanter. This is the line of the osteotomy.

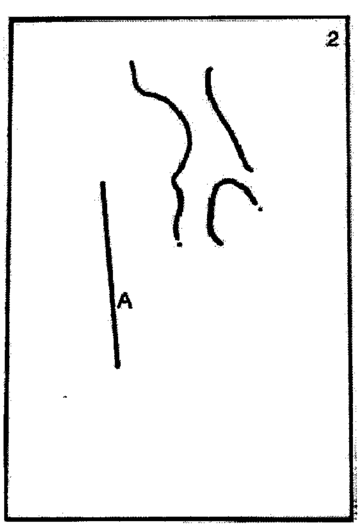
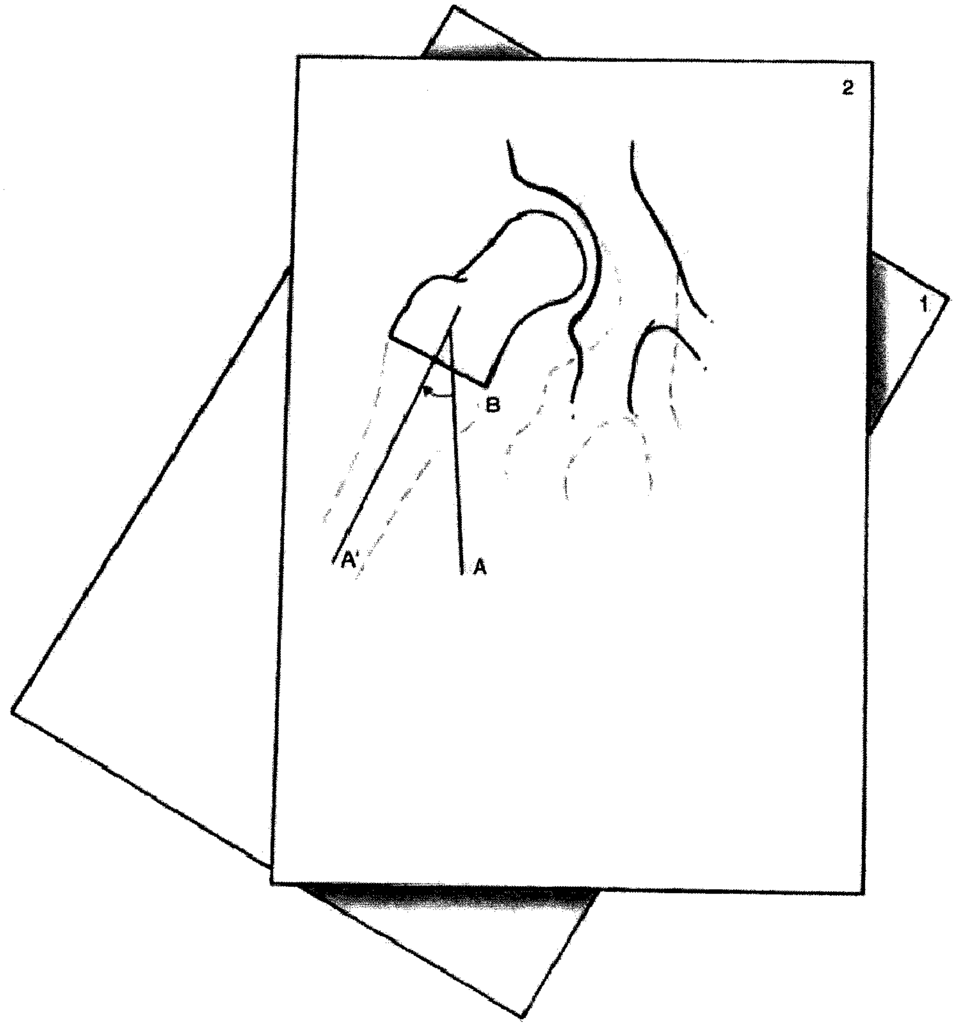


FIGURE 23-60. The second drawing, on a separate sheet of paper, traces the outline of the acetabulum. Again, a line is drawn down the axis of the femoral shaft (A).

FIGURE 23-61. The second drawing is superimposed on the first one. The drawings are turned until the femoral head on the first drawing is in the desired relationship to the acetabulum of the second one. The proximal femur is drawn in down to the osteotomy line (B) along with the new femoral axis A′ and the line of the osteotomy (B). The amount of varus that is needed to produce the desired result is found by measuring the angle between the original femoral axis (A) and the new femoral axis A′.



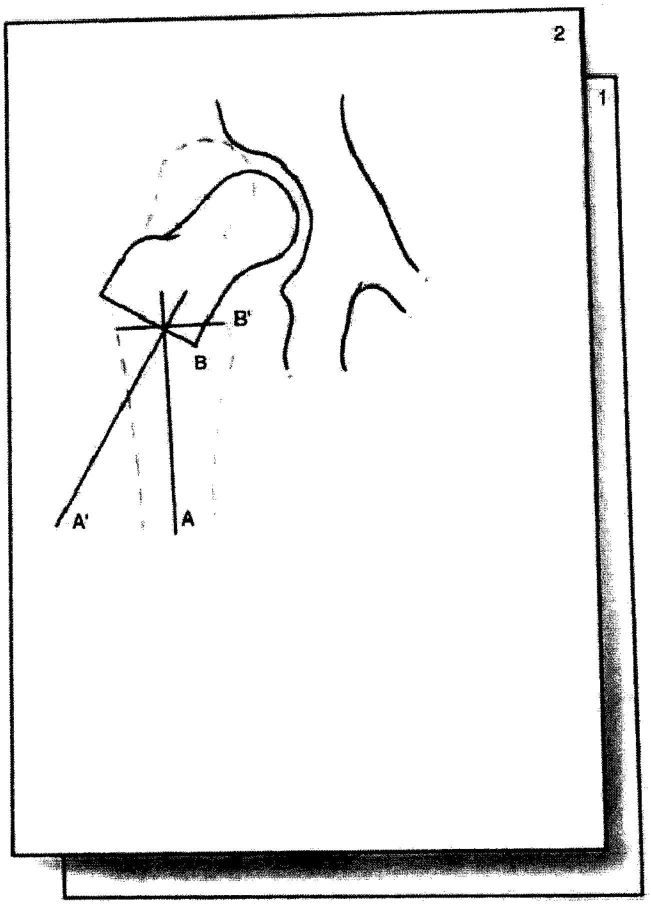


FIGURE 23-62. The two drawings are superimposed, aligning the femoral axis (A) of each. The second drawing is slid up and down until the intersection of A' and B of the second drawing intersects with line B on the first drawing. At this point, line B' is drawn perpendicular to the axis of the femoral shaft (A). This is the definitive osteotomy line. The wedge that lies below the definitive osteotomy line B' is the wedge that will be resected. Because the femoral axis remained superimposed, the correct amount of medial displacement is accounted for, and there is no change in the alignment of the leg.

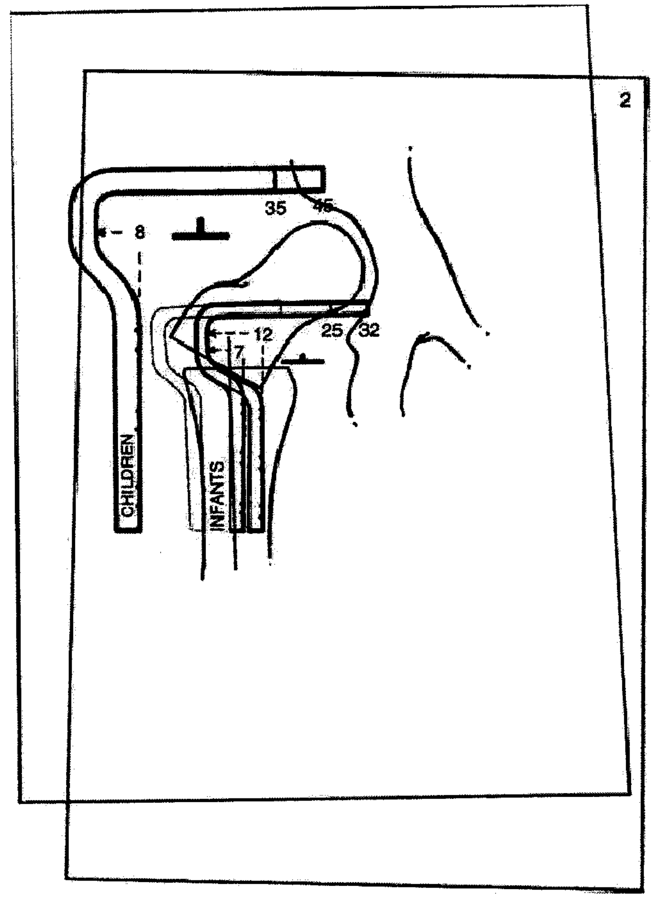


FIGURE 23-63. The distal part of the femur is drawn in below the osteotomy line. If blade plates are used as a means of internal fixation, the insertion point of the chisel can be determined. For the adult-sized plate, this is about 12 to 15mm proximal to the osteotomy site. For the juvenile and adolescent plates, this distance is less and can be determined from transparent templates or measurement from the desired size of plate. On this same drawing, the correct amount of displacement can also be measured and the correct plate selected. Finally, the desired length of the blade can be measured and the blade plate drawn in. This should represent what the postoperative radiograph will look like.

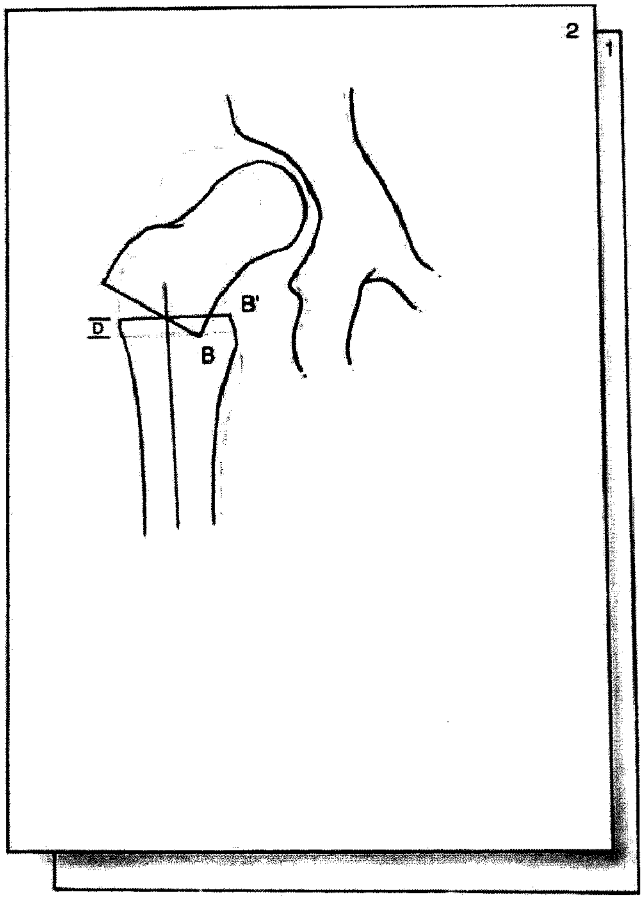


FIGURE 23-64. The amount of shortening that the osteotomy produces can be determined directly from the drawings. The femoral axis (A) of both drawings is aligned and the acetabular joint line of each is superimposed. The amount of shortening produced (D) is the distance between the osteotomy line (B) of the first drawing and the definitive osteotomy line (B') of the second drawing.

Postoperative Care. Subtrochanteric osteotomies usually take 6 to 8 weeks to heal. The degree of immobilization or bed rest during this period depends on many factors: the size of the child and hence the strength of the plate used, the strength of the bone, the stability of the osteotomy, and the ability of the patient to cooperate with partial weight bearing. We prefer to place small children in a one-leg spica cast at bed rest. Cooperative children between 8 and 12 years of age can usually be left out of the cast during bed rest or given the use of a wheelchair. In the adolescent group, the fixation is usually strong enough to permit a partial weight-bearing crutch gait if the patient is cooperative. Full weight bearing is permitted in all age groups when there is radiographic evidence of bony union.

In young children under 5 years of age, many physicians may choose to do the osteotomy using an Altdorf clamp for fixation. The Altdorf hip clamp is a 130-degree angled malleable blade plate (Fig. 23-80). Wagner (403) described the technique for using the plate, which greatly simplifies an intertrochanteric osteotomy (Figs. 23-75 to 23-79). Wagner did not use a cast with this plate unless other procedures dictate it.

This plate is most useful in children younger than 5 to 6 years of age who are undergoing a femoral osteotomy in conjunction with treatment of DDH (404). It can also be used in children up to 12 (418). Although this plate is designed for varus osteotomies, the fact that it can be easily bent makes it ideal for the treatment (by valgus osteotomy) of developmental coxa vara in small children.

In small children, any leg-length discrepancy resulting from varus osteotomy should resolve by growth stimulation and restoration of the normal neck-shaft angle (405). In teenagers, however, more than a 15-degree lessening of the neck-shaft angle may result in limb shortening. If the varus osteotomy is excessive, it can cause lateralization of the shaft, shifting the mechanical axis medial to the knee joint and leading to mechanical abnormalities at the knee (406). Proximal femoral osteotomy may, in some cases, be indicated in order to correct residual deformity from a partial physeal arrest resulting from aseptic necrosis; however, minimal literature exists on this procedure.

If the osteotomy is transfixed with smooth wires, they can be removed after 6 to 8 weeks. Internal fixation devices are usually removed 12 to 18 months postoperatively; if they are not removed in young children, they become encased within the proximal femur, and this could pose problems if future operations become necessary.

In the adolescent or adult patient with residual acetabular dysplasia and a disrupted Shenton line in whom there is no potential for acetabular growth and remodeling, changing the orientation of the proximal femur does not increase the weight-bearing area, but only shifts the weight-bearing area to another portion of the femoral head (407–409). Proximal femoral osteotomies in the adolescent or adult group are indicated only as adjuncts to pelvic operations and in extreme cases of coxa valga and subluxation (185, 408) (Fig. 23-81).

In general, it is the authors' preference in children with complete dislocations under 18 months of age to do only a reduction, closed or open. In children older than 18 months with complete dislocation or subluxation or residuals of dysplasia or subluxation after treatment it is the author's preference to correct all anatomic abnormalities on both the femoral and acetabular side of the joint.

Role of Pelvic Osteotomies. Indications for the treatment of residual radiographic acetabular dysplasia after closed or open reduction (or discovered incidentally) depend on the age of the child and whether the patient has symptoms (410). The goal of treatment is to restore the anatomy to as near normal as possible by the time skeletal maturity is attained. As discussed previously, after concentric reduction is obtained and maintained, the potential for

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Proximal Varus Osteotomy in Children Using a 90-Degree Blade Plate (Figs. 23-65 to 23-73)

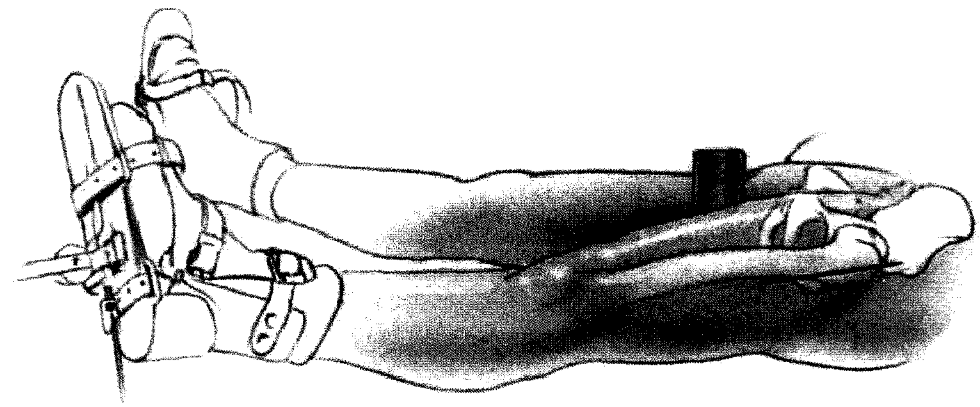


FIGURE 23-65. Proximal Femoral Varus Osteotomy in Children Using a 90-Degree Blade Plate. An intertrochanteric femoral osteotomy can be performed on a fracture table or on a regular operating table with a translucent top, depending on the surgeon's preference. The surgeon without an assistant may find it easier to place the larger adolescent patient on a fracture table to control the leg more easily. Many fracture tables do not accommodate small children or permit bilateral hip surgery, making the choice obvious. To position children without a fracture table, it is useful to roll or fold a sheet with tape wrapped around it with the sticky side out. This prevents the child from shifting off the bolster during the surgery.

The patient should be positioned so that anteroposterior and lateral views of the hip can be obtained on an image intensifier. This is necessary to confirm the correct placement of the osteotomy and blade of the fixation device. For the patient who is not on a fracture table, the hip may be placed in the "frog-leg" position.

The incision should extend from the tip of the greater trochanter as far distally as necessary. The distal extent of the incision depends on the fixation device used and the type of osteotomy; a shortening osteotomy requires a longer incision.

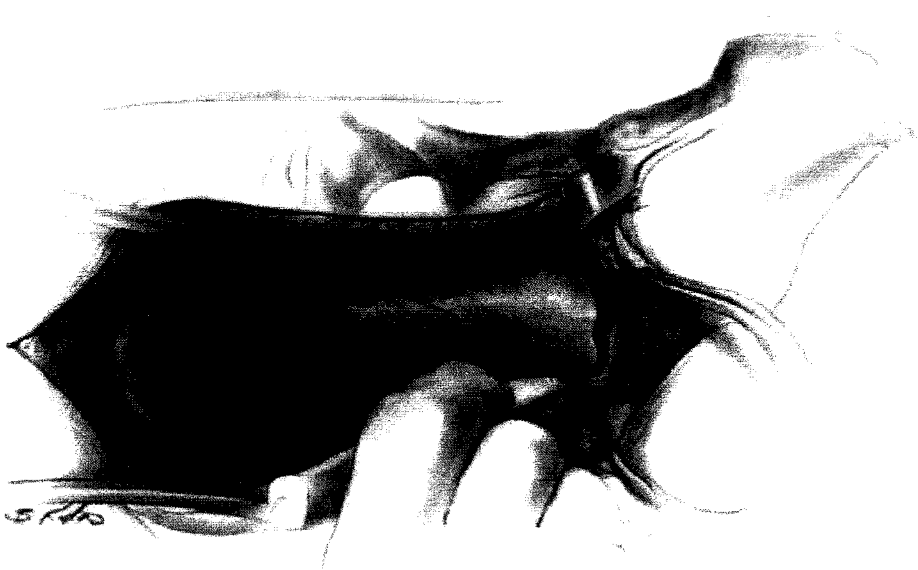


FIGURE 23-66. After the incision is deepened through the subcutaneous fat and fascia lata, two self-retaining retractors are placed beneath the fascia lata. The vastus ridge, where the vastus lateralis muscle inserts, is identified, and the cautery current is used to cut through this muscle. This cut in the vastus lateralis muscle should extend from the anterior femoral shaft posteriorly to the point where the insertion ends.

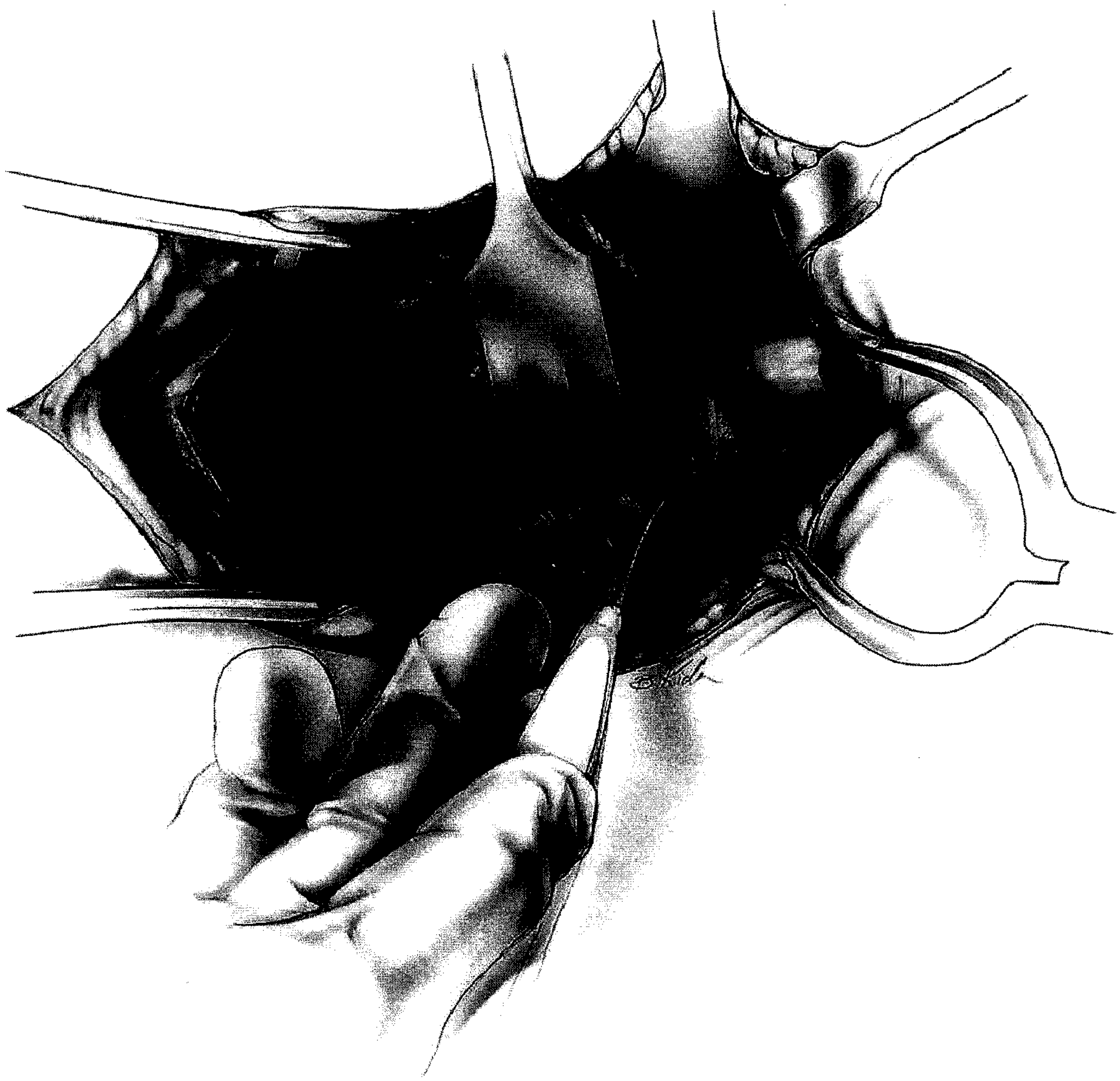


FIGURE 23-67. A sharp rake is used to pull up the belly of the vastus lateralis muscle, exposing its posterior attachment into the femur at the linea aspera. This muscle should be divided as close to this attachment as possible because all the muscle posterior to the division will be denervated. It is not wise to cut the muscle at its attachment because two to three large vessels will be encountered coming around the posterior aspect of the femur to enter the muscle. Therefore, the muscle is divided about 1 cm anterior to its attachment. This can be done carefully, with the cautery current, or bluntly, by pulling a periosteal elevator from cephalad to caudad, tearing the muscle, and dividing the periosteum. With care and a bit of luck, these perforating vessels can be identified and cauterized before they are divided.

FIGURE 23-68. A periosteal elevator is used to elevate the entire quadriceps muscle group from the bone. In elevating the muscle from the medial side of the femur, care must be taken to stay in a subperiosteal location. A curved elevator (e.g., a curved Crego elevator) is helpful in this regard. The same is true for elevating the attachments off the linea aspera; a sharp elevator or osteotome should be kept in close contact with the bone, even elevating small fragments of bone. This reduces bleeding, which is greatest in this area. The amount of circumferential periosteal elevation that is achieved depends on the type of osteotomy performed. A varus osteotomy without rotation requires the least elevation, whereas a rotational osteotomy requires the most elevation, to allow the bones to rotate untethered by the linea aspera.

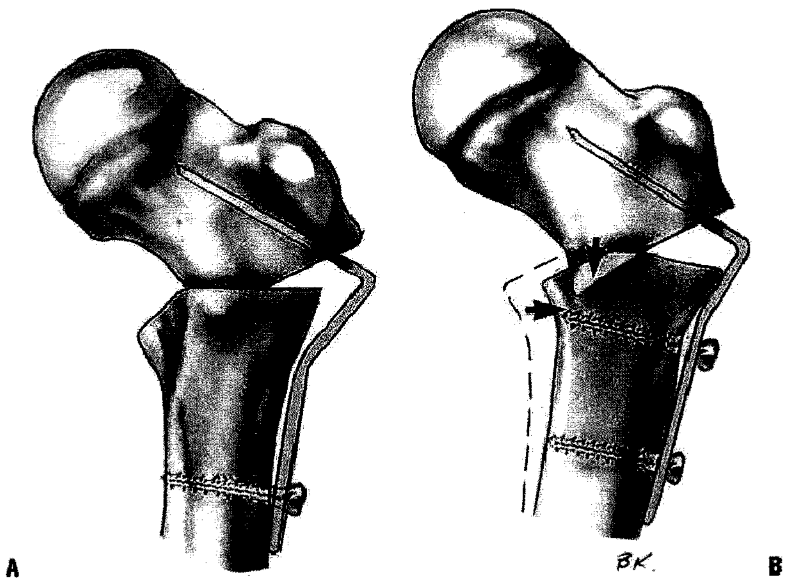


FIGURE 23-78. The angle of the Altdorf clamp is 130 degrees, but the clamp can be bent with pliers or plate benders to the required angle. In most cases of varus osteotomy, the 130-degree angle is ideal. The Altdorf clamp is designed to be pushed into the cut surface of the proximal fragment and not through the lateral cortex. To accomplish this, the proper size of clamp is grasped with the holding device.

Medial displacement is controlled by the point at which the splines of the clamp enter the proximal fragment. The more medially the splines enter the proximal fragment, the more medial is the displacement achieved. The amount of varus achieved depends on the angle at which the blade enters the femoral neck. To judge the angle for insertion of the blade, the fragments are held in the desired position while the splines are first pushed into the cancellous bone of the femoral neck and then impacted with a mallet.

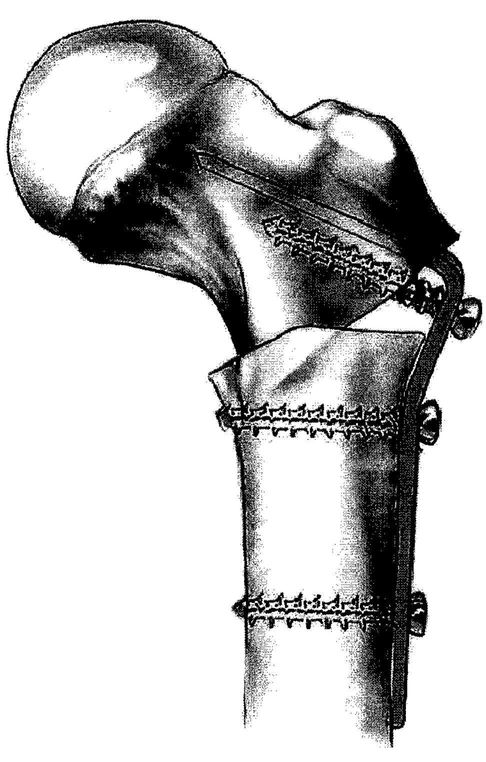
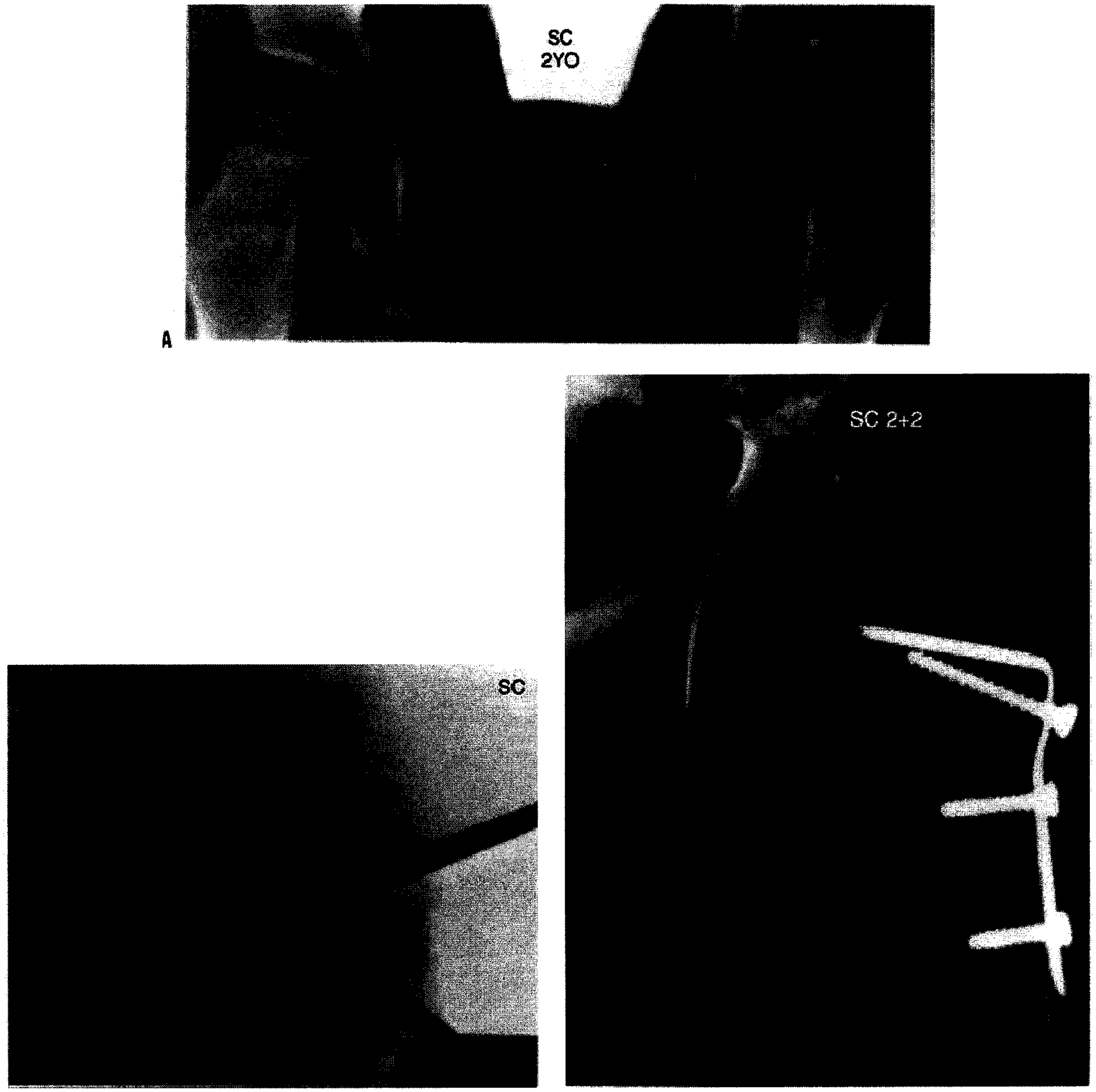


FIGURE 23-79. Finally, a 4-mm cancellous screw is inserted through the proximal round hole into the proximal fragment. This screw should not be longer than the bifurcated blade, in order to avoid penetrating the physeal plate.

Traditionally, the treatment options for residual acetabular dysplasia are divided into four groups. The first group consists of osteotomies of the pelvis that redirect the entire acetabulum. This redirection provides coverage of the femoral head by acetabular articular cartilage. These osteotomies include the Salter innominate osteotomy (41, 76, 322–324, 357, 417–419) (Fig. 23-82), the Sutherland double-innominate osteotomy (420), the triple-innominate osteotomies of Tonnis (185, 421–425), Steel (426–432) and Ganz (406, 433–436), the spherical osteotomies of Wagner (437–439) and Eppright (409, 440), and others (441–449). These procedures involve complete cuts through various pelvic bones and rotation of the acetabulum.

The general prerequisites for rotational osteotomy include complete concentric reduction and release of muscle contractures, including the iliopsoas and hip adductors; a congruous joint; and a good range of motion. Rotational pelvic osteotomies in the face of subluxation may lead to severe damage to the femoral head. These procedures are best performed before 6 years of age, but the age limits vary considerably, depending on the surgeon.

The Salter innominate osteotomy (Figs. 23-83 to 23-85), which hinges on the symphysis pubis, is better performed in the infant, child, or adolescent, because of the flexibility of the symphysis pubis in young patients. However, this osteotomy



A B C

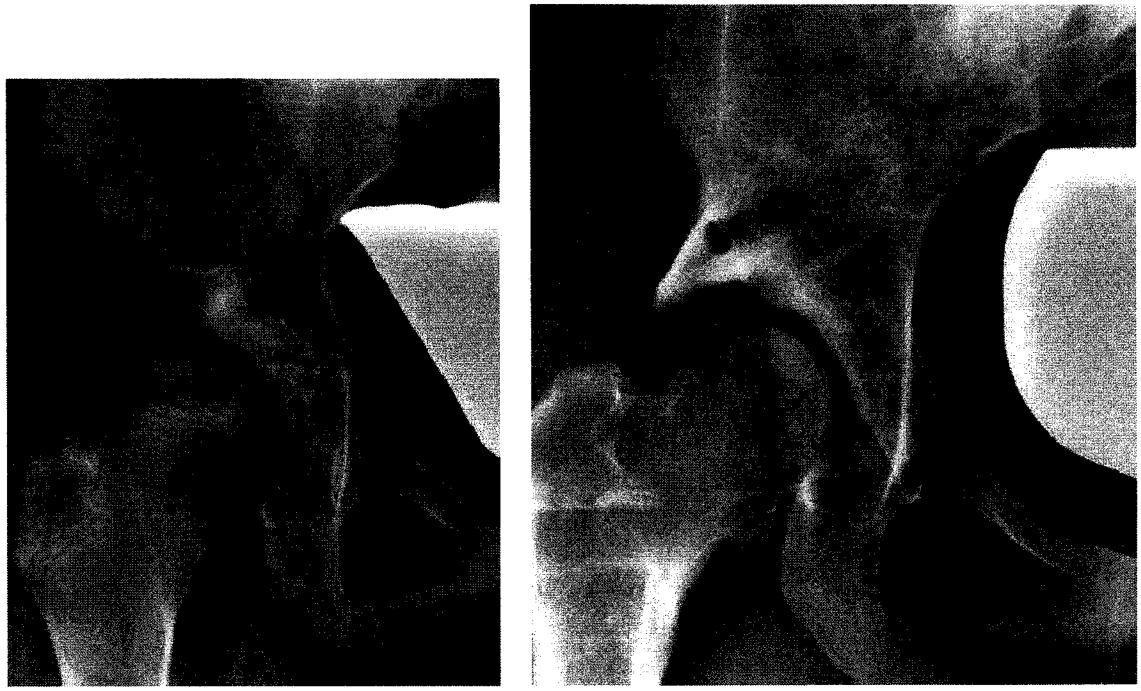
FIGURE 23-80. SC is a 2-year-old girl who underwent a closed reduction of the left hip at 3 months of age. Radiograph **(A)** showed persistent widening of the joint and failure of the acetabulum to remodel. A varus and rotational osteotomy was performed. The position of the femur was ascertained interoperatively by image intensifier **(B)**. The position of the femoral head in relation to the acetabulum and the healing osteotomy is shown 6 weeks after surgery **(C)**.

The fact that this method of fixation is used most often in young children in combination with other procedures for congenital dislocation of the hip implies that a cast is usually required. In addition, the difficulty in executing this osteotomy to perfection, which is what produces the compression and stability (along with the malleable plate and only two screws for fixation), tends to make most surgeons uncomfortable treating children without cast immobilization.

can be performed in adults as well (324). The procedure is more likely to succeed when the CE angle is >10 degrees (364).

In 1961, Salter described an operation based on a new principle: redirection of the entire acetabulum as a unit. This was accomplished by performing a transverse osteotomy of the ilium just above the acetabulum and opening the osteotomy anterolaterally by hinging and rotating the acetabular segment on the symphysis pubis (322, 323). It was designed to preserve the normal acetabular structures and shape while correcting the abnormal anterolateral facing of the acetabulum seen in late cases of DDH.

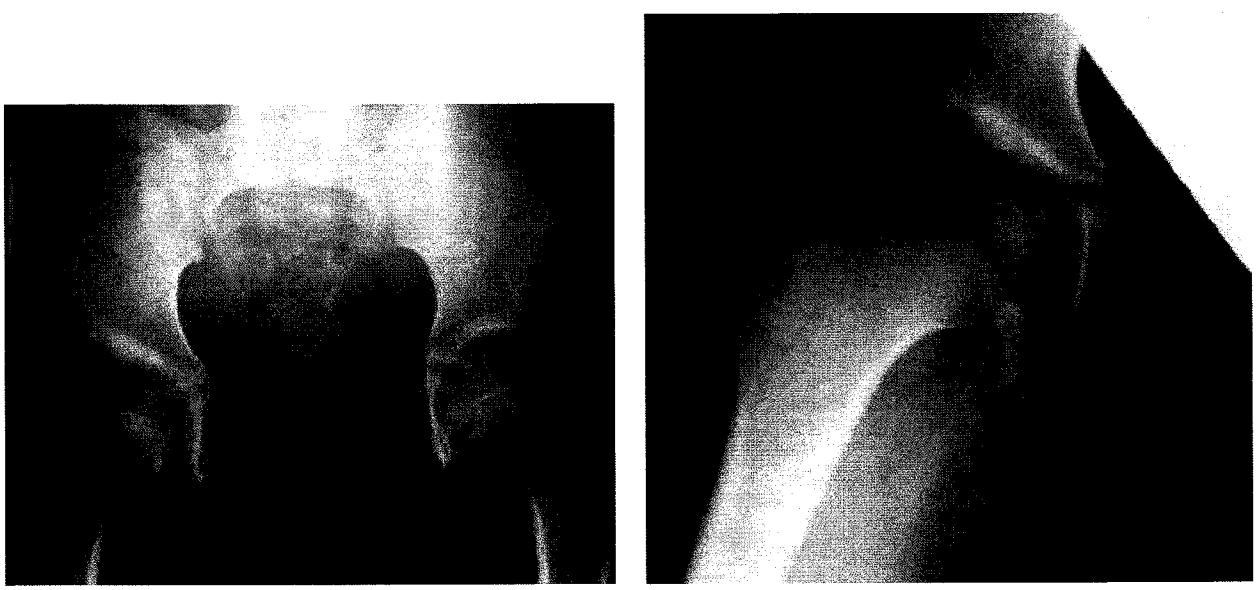
This is probably the most widely used and written-about pelvic osteotomy in the treatment of DDH. Subsequent reports have largely confirmed Salter and Dubos' (323) results (357, 361, 364, 376). Because of the apparent ease with which this procedure can be performed, it is also the most poorly performed and misapplied. The judgment involved in the application of



A B

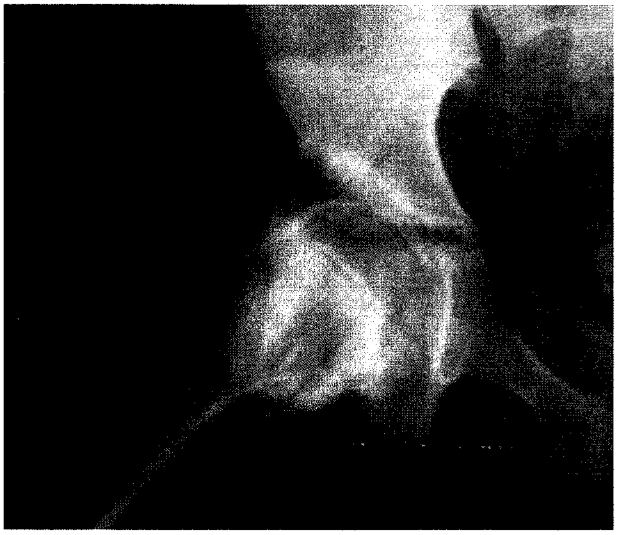
FIGURE 23-81. A 10-year-old girl whose developmental dysplasia of the hip was diagnosed at 5 years of age. She had previously undergone open reduction, but had residual proximal femoral and acetabular deformities. **A:** Preoperative anteroposterior radiograph of the pelvis. **B:** Three years after varus derotation osteotomy and Staheli slotted acetabular augmentation.

Salter osteotomy and its proper technical execution are not easy. One of the most obvious and common errors is the failure to obtain a concentric reduction before performing the osteotomy. The biomechanical aspects of the osteotomy have been studied. The Salter innominate osteotomy provides about 15 degrees of lateral coverage and 25 degrees of anterior coverage, although many clinicians believe that more lateral coverage can be obtained. Wong-Chung and colleagues (450) have demonstrated that there is no significant lateralization of the hip in a properly performed osteotomy (Fig. 23-86).



A B

FIGURE 23-82. An 8-year-old girl with residual right acetabular dysplasia. **A:** Anteroposterior radiograph of the pelvis. **B:** Anteroposterior view of the pelvis with abduction, flexion, and slight internal rotation; the femoral head appears slightly uncovered. **C:** Similar view with the addition of an arthrographic dye. Note the excellent coverage of the proximal femur by unossified acetabular cartilage. **D:** Immediately after the innominate osteotomy. **E:** Four years after the innominate osteotomy.


C


D

FIGURE 23-82. *(continued)*


E

The patient is positioned as for open reduction of the hip through the anterior approach, and the same incision and approach are used. If an open reduction of the hip is not to be performed at the same time, it is not necessary to expose the hip capsule.

The double-innominate osteotomy of Sutherland and Moore, although rarely performed today, aims to allow greater rotation of the pelvic fragment by cutting through the pubis, instead of merely hinging on it (420). Complications of this procedure can involve injury to the spermatic cords, bladder, and urethra. The triple-innominate osteotomy allows even greater coverage by means of cuts of all three hip bones (234).

The triple-innominate osteotomy of the pelvis (Figs. 23-87 to 23-92) divides the iliac bone, as in the Salter osteotomy, while it also divides the pubic and ischial bones. It is a reconstructive procedure because it uses the articular cartilage and the subchondral bone of the acetabulum. In this respect, it is similar to the osteotomies of Salter and Pemberton. It differs from these osteotomies, however, in that there is no hinge: The acetabular fragment is completely free. This permits a greater degree of mobility in obtaining anterior and lateral coverage (Fig. 23-93). Subsequent reports have demonstrated the effectiveness of this procedure (234, 426–431). As in the Salter osteotomy, a prerequisite for the triple-innominate osteotomy is that the femoral head and the acetabulum are congruous after the osteotomy is completed. It is indicated when this condition can be met but when adequate coverage of the femoral head cannot be achieved with the Salter or Pemberton osteotomy, preoperative traction or femoral osteotomy with or without shortening can be used to ensure a concentric reduction of the femoral head. The operation, as originally described by Steel (390), used a separate incision on the buttocks to divide the ischium while dividing the pubic ramus through the same incision that is used to divide the iliac bone. Division of the ischium is a difficult portion of the procedure. Some surgeons have adapted the approach used by Le Coeur (451) in his osteotomy to divide the ischium and the pubis through a groin incision similar to that used in adductor myotomy or proximal hamstring release. Tonnis (185) has described a triple-innominate osteotomy in

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Innominate Osteotomy of Salter (Figs. 23-83 to 23-85)

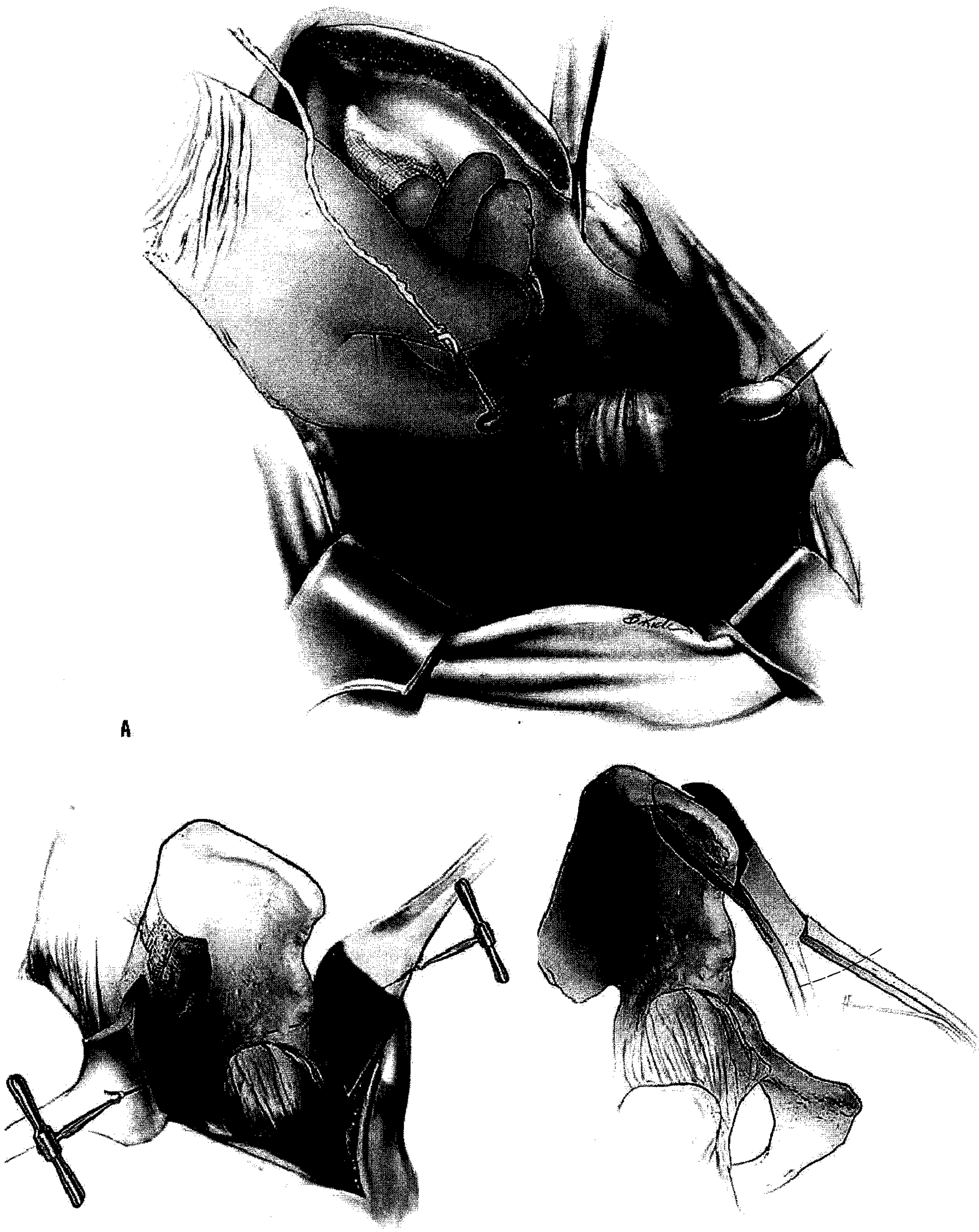


FIGURE 23-83. Innominate Osteotomy of Salter. The inner and outer tables of the ilium are exposed. The periosteum is elevated carefully from the sciatic notch with a curved periosteal elevator, such as a Crego or Cobb elevator. A right-angled forceps is passed medial to lateral while the finger of the other hand is used to push the periosteum down and away from the sciatic notch on the outer table. A Gigli saw is grasped in the forceps and pulled through the sciatic notch **(A)**. Retractors are placed in the sciatic notch on each side of the ilium to provide wide retraction and protection of the soft tissues. The osteotomy is performed with the Gigli saw, which emerges at or just above the anterior inferior superior iliac spine. While using the Gigli saw **(B)**, the hands should be spread as far apart as possible and constant tension kept on each end of the Gigli saw because it has a tendency to bend. The bone graft that is used to hold the osteotomy site open is taken from the anterior iliac crest. This can be done with a bone biting forceps in young children **(C)** but is facilitated by the use of a power saw in older children. At this point, it is imperative to perform an intramuscular tenotomy of the iliopsoas, as described in the anterior approach to the congenitally dislocated hip.

FIGURE 23-84. Towel clips are used to grasp the two fragments. The proximal fragment is grasped and held, not to help pull open the osteotomy site but rather to stabilize the pelvis. Any upward movement of this proximal fragment creates a spurious correction and the appearance of a high iliac crest simulating a leg-length inequality. The distal fragment is grasped as far posteriorly and as close to the hip capsule as possible **(A)** to avoid a tendency to break off a piece of bone. If the hip capsule has not been opened, the leg can be used to produce the desired correction in the acetabulum. This is done by placing the foot on the opposite knee in the figure-4 position. Pushing down on the knee and pulling the heel toward the patient's chin produces the desired rotation. If the capsule has been opened **(B)**, the towel clip grasping the distal fragment is used to rotate this fragment downward, in line with the ilium **(C)**. At the same time, this fragment, which probably slipped posteriorly after the osteotomy, should be pulled forward. It is this rotation that accounts for the difference in shape of the obturator foramen, which is seen on the postoperative radiograph. The bone graft is tailored to fit tightly in the gap that has been created in the osteotomy and is inserted. This graft should be relatively stable after it is inserted. Its stability can be tested by pulling on the graft with a Kocher clamp. After the graft is inserted, the posterior aspect of the osteotomy should be closed, and the distal fragment should not be displaced posteriorly relative to the proximal fragment. Kalamchi (417) has suggested a modification, placing a notch in the posteriorly cut surface of the proximal fragment and inserting the posterior edge of the distal fragment into the notch. This increases the stability and helps avoid posterior displacement of the distal fragment.

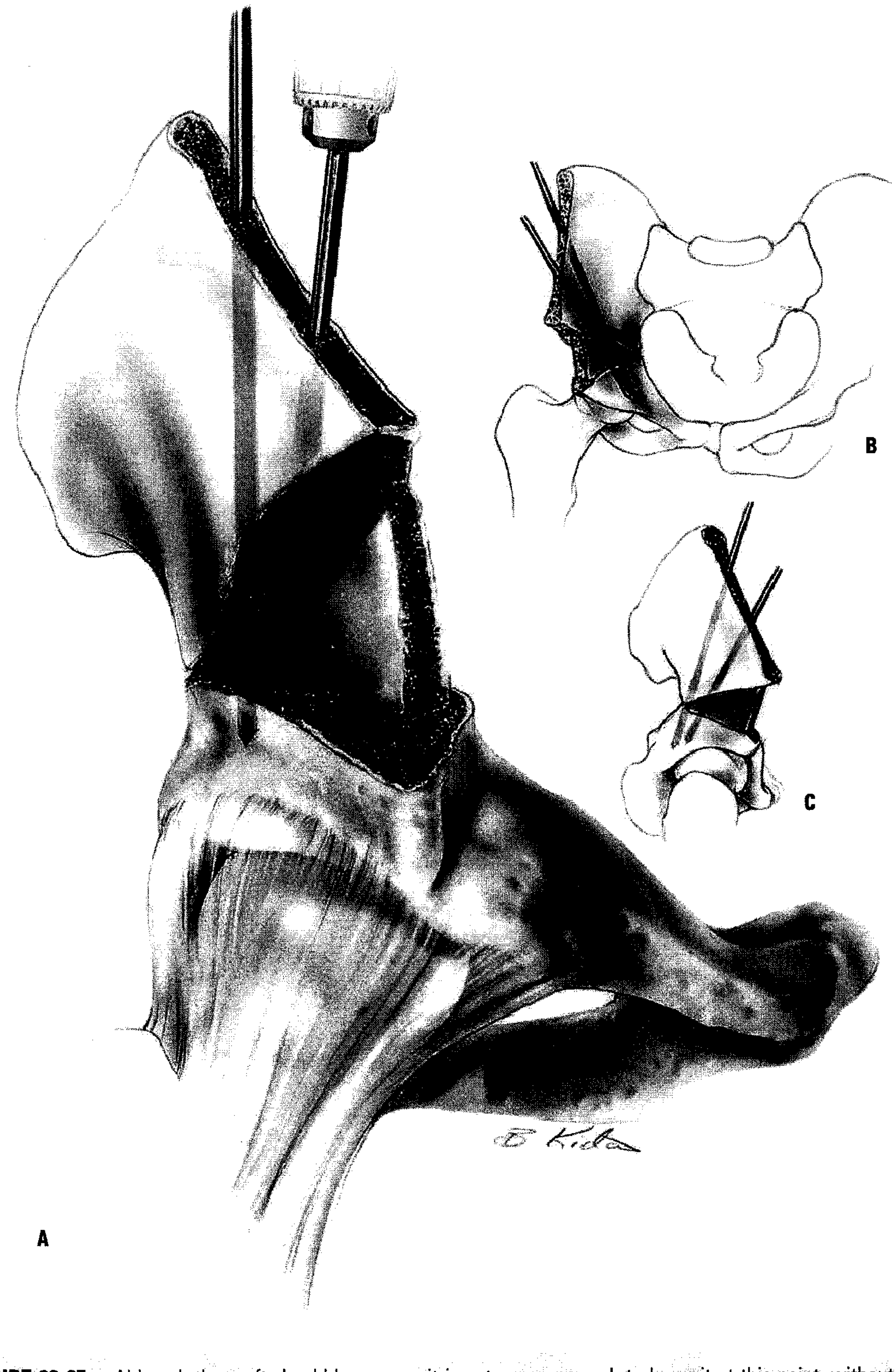
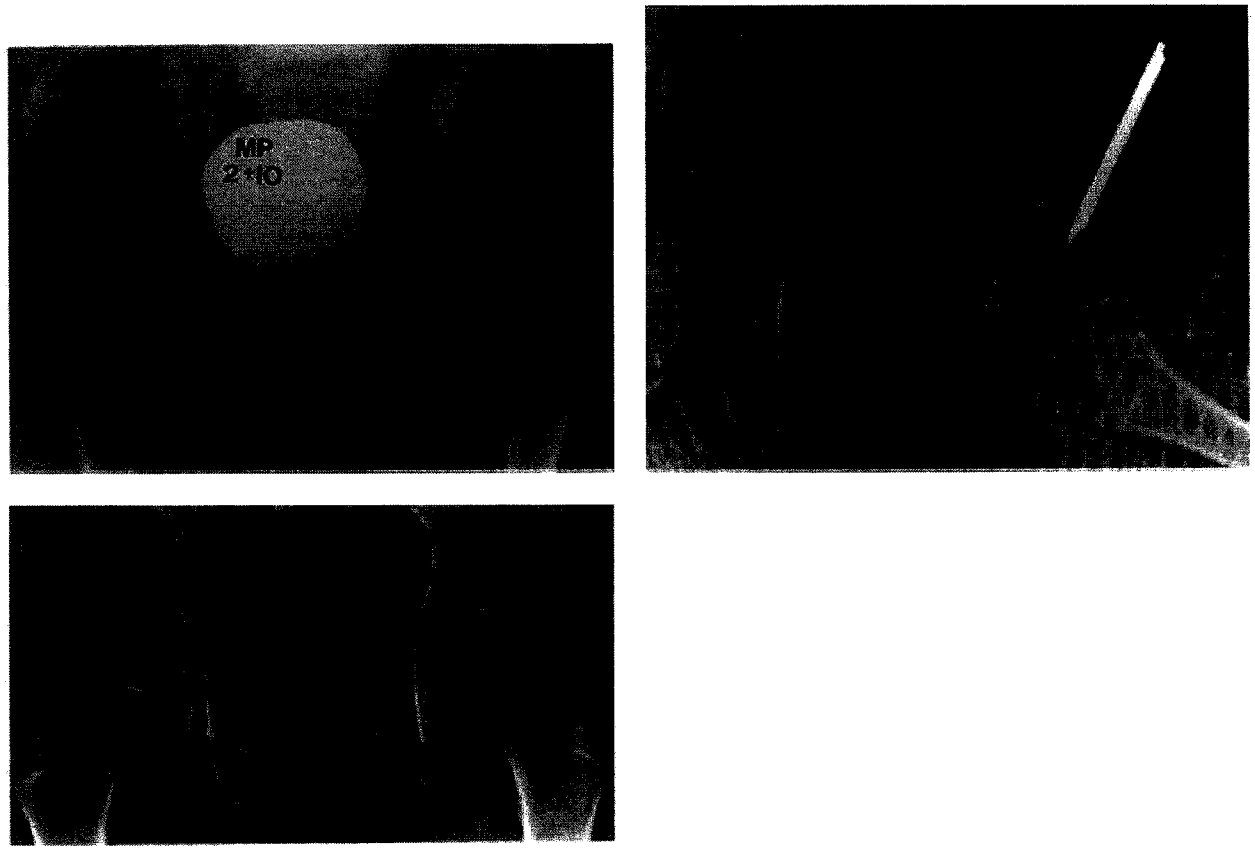


FIGURE 23-85. Although the graft should be secure, it is not secure enough to leave it at this point, without fixation. Smooth or thin wires should not be used. Two heavy-threaded Kirchner wires should be used and passed from the proximal fragment into the distal fragment **(A)**. In the distal fragment, they should lie medial and posterior to the acetabulum **(B, C)**, and this determines their starting point in the proximal fragment. There is a danger of passing one of the wires into the hip joint when the capsule has not been opened, as in the treatment of acetabular dysplasia. This danger and the fact that properly placed pins appear to penetrate the hip joint on the postoperative radiograph make it imperative that the surgeon has a good grasp of the pelvic anatomy and that he or she carefully moves the hip to feel and listen for crepitus. After this the wound is closed. A drain is usually not necessary when only an innominate osteotomy has been performed.



A B C

FIGURE 23-86. MP is a 2-year, 9-month-old girl **(A)** in whom there have been no signs of acetabular remodeling 18 months after closed reduction of a congenitally dislocated hip. In addition, there is excessive femoral anteversion. It was decided to correct these problems with an innominate osteotomy, as described by Salter. Six weeks after the osteotomy **(B)**, certain features are observed. The posterior aspect remains closed, and posterior displacement of the distal fragment was avoided. The pins could have been inserted further, continuing down into the ischium behind the hip capsule. Also, there was more lateral than anterior rotation achieved, as evidenced by only a slight asymmetry of the obturator foramen. At 6 years and 1 month of age **(C)**, the resulting containment is good, as evidenced by the development of the hip. Postoperative immobilization depends on the circumstances. In older children and teenagers who are deemed reliable with a three-point, partial weight-bearing crutch gait, no immobilization and early ambulation can be permitted. Young or untrustworthy children should always be immobilized for 6 weeks before weight bearing is permitted. If an open reduction is performed at the same time, the hip is immobilized in accordance with the treatment for that procedure.

which the ischium is divided closer to the acetabulum than in the Steel osteotomy.

Postoperatively, the patient is usually placed in a spica cast. In the more reliable patient, this can be a single-leg spica. In older patients who rely on crutches and in whom the fixation is secure, balance suspension can be used immediately after surgery until motion and comfort are restored, and then a partial weight-bearing crutch gait is begun. The healing time for this osteotomy depends on the patient's age but generally is longer than the healing time of the Salter osteotomy for people of the same age. Young children can heal in 8 weeks, whereas in young adults healing may take 12 weeks or longer.

An important factor to be considered when planning correction of acetabular dysplasia by one of the rotational procedures is the amount of dysplasia that needs to be corrected. The amount of coverage obtained by osteotomies such as the Salter procedure is limited, whereas osteotomies that cut all three pelvic bones provide the ability to obtain greater coverage (402, 452–454). The closer the cuts are placed to the acetabulum, the greater the femoral head coverage. The triple-innominate osteotomies described by Tonnis and Ganz provide greater rotational possibilities than the one described by Steel (Fig. 23-94). The osteotomies that are closest to the acetabulum (e.g., Eppright, Wagner, and Naito procedures) provide the greatest potential for redirection, but these require significant technical expertise and have higher rates of complications (412).

The most popular rotational osteotomy in patients with dysplasia and when the triradiate cartilage is closed is the periacetabular osteotomy (PAO) described by Ganz. The Ganz

Text continued on page 1059

Triple Innominate Osteotomy (Figs. 23-87 to 23-92)

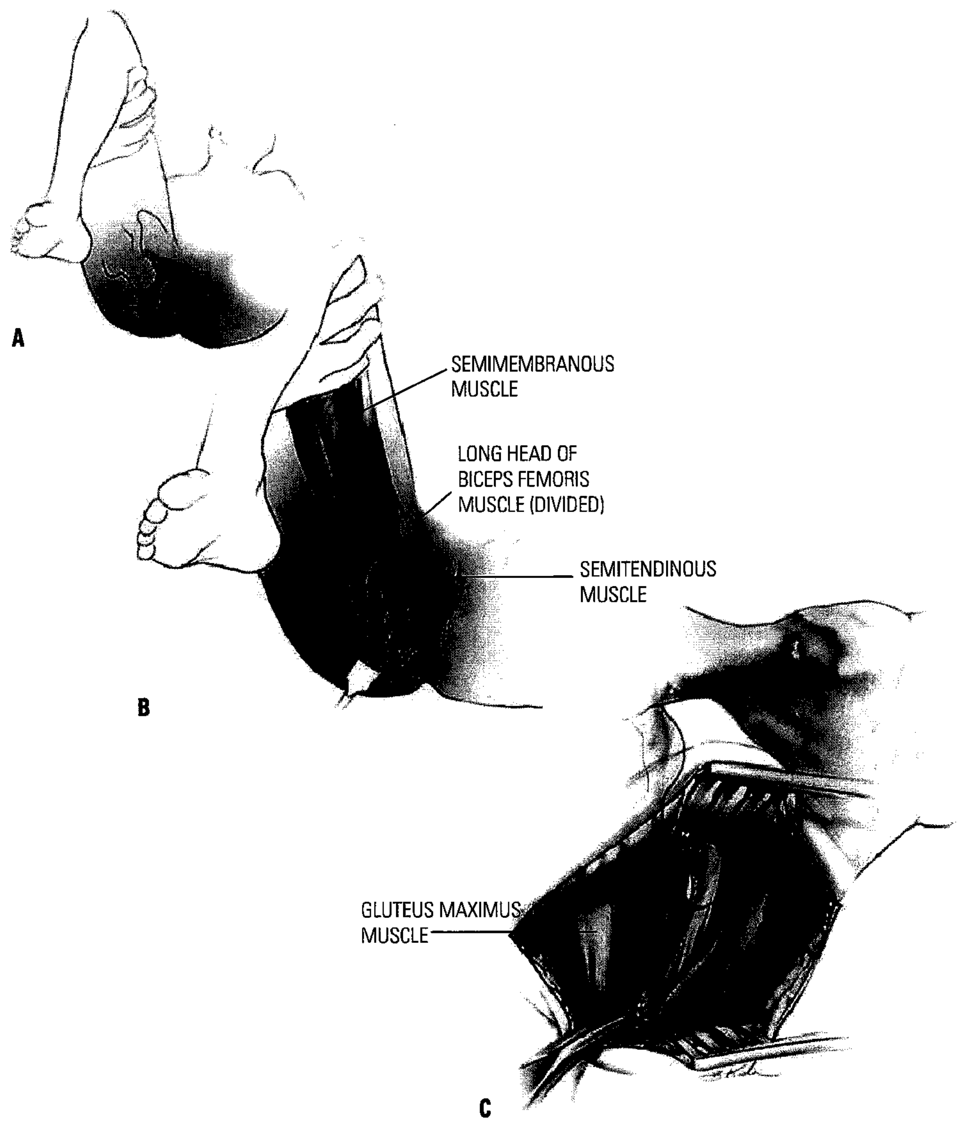


FIGURE 23-87. Triple Innominate Osteotomy. The patient can be positioned in the lateral decubitus position, as described for anterior open reduction of the hip. If the surgeon desires, the entire first part of the procedure can be done with the patient in the lateral position and the hip flexed to 90 degrees. This also facilitates the remainder of the procedure because the flexion and internal rotation of the hip facilitate the pubic osteotomy, in particular.

In the operation described by Steel (429), the entire leg and buttocks area are prepared and draped free. The operation starts with a transverse incision **(A)** about 1 cm cephalad from the natal crease. This incision is deepened down to the gluteus maximus muscle. It is important to gain a wide exposure in all directions at this point, or the remainder of the exposure will be difficult. The medial border of the gluteus maximus muscle is identified and freed, allowing the muscle to be retracted laterally, exposing the muscle attachments to the ischial tuberosity.

The biceps femoris and the semitendinous muscles insert by a common tendon. The tendinous insertion of the semimembranosus muscle lies lateral to this, and the sciatic nerve lies lateral to the semimembranosus insertion. If the long head of the biceps femoris is dissected free and detached **(B)**, the interval between the semitendinosus and the semimembranosus muscles can be identified. This interval is the ideal site for the osteotomy of the ischium. It is best to expose this osteotomy site sufficiently so that at least 1 cm of bone can be removed. This ensures that no periosteum is holding the bone ends together, a situation that may limit mobility of the fragment. In addition, it allows some medial displacement of the acetabular fragment, which tends to be lateralized with this procedure.

The ischial ramus is dissected subperiosteally. It is usually not possible to stay subperiosteal all the way around, but care must be taken to remain in close proximity to the bone. A curved kidney pedicle forceps or retractor, such as a wide-curved Crego retractor, is passed around the ischium and out through the obturator foramen to elevate the obturator muscles and protect the internal pudendal vessels and nerve **(C)**. The initial cut can be as that described by Steel (4); however, many surgeons find it easier to remove a section of bone with a rongeur. This has the added advantage of providing more mobility to the fragments, which tend to be held together by the thick periosteum and the surrounding ligaments. When this is completed, the wound is closed.

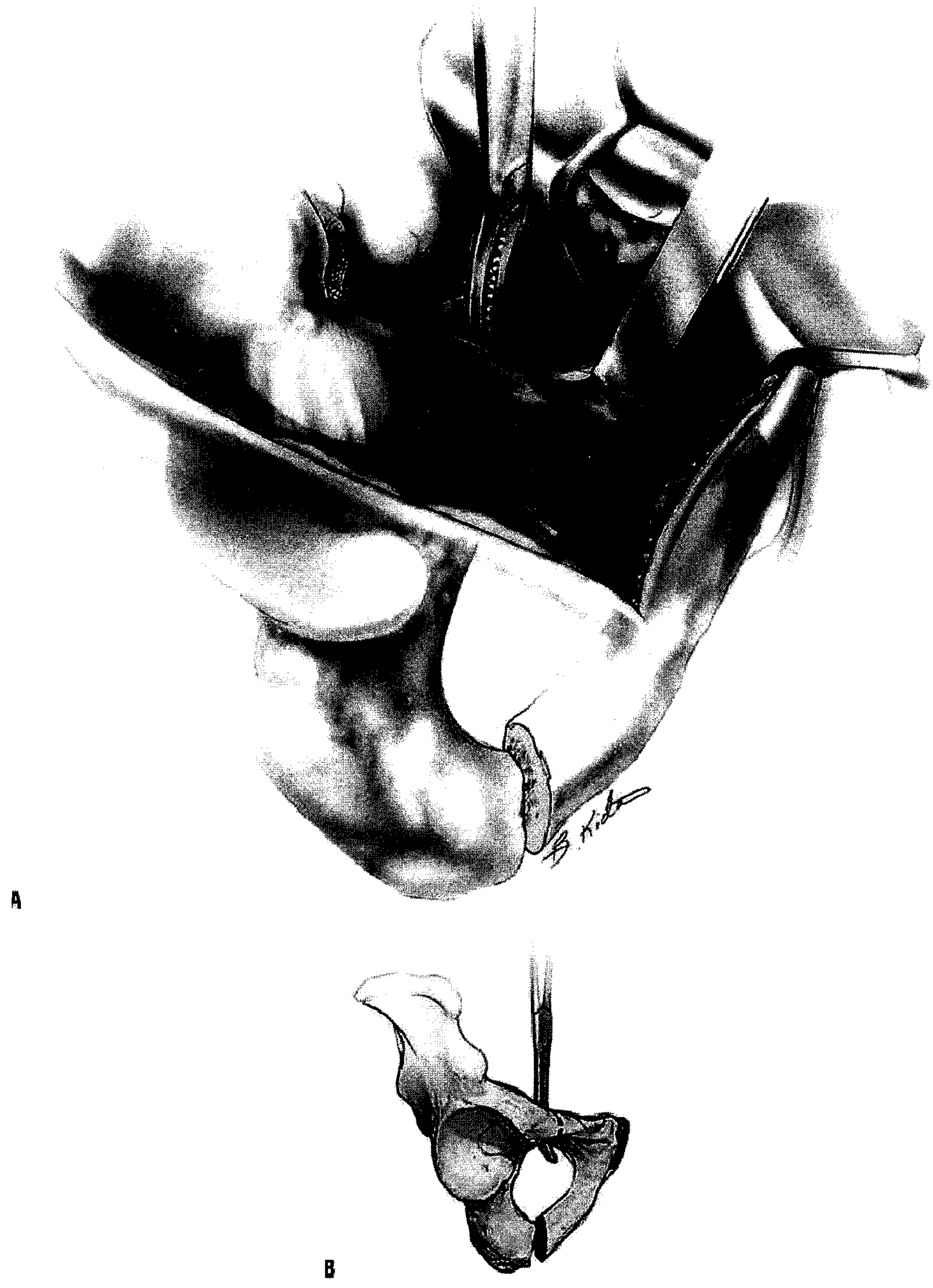
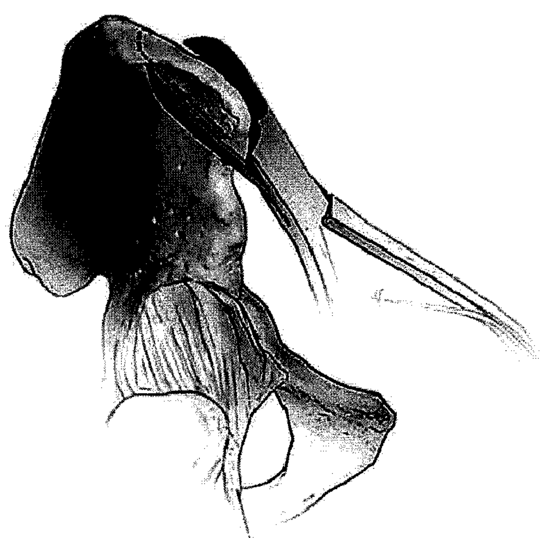


FIGURE 23-88. An oblique incision is made, and the innominate bone is exposed, as in the Salter osteotomy. The osteotomy of the pubis requires a medial exposure of the pubic ramus that taxes the limits of the incision. This exposure is facilitated by having the assistant push the leg across the table in flexion and adduction. This pushes the patient into a more lateral position while relaxing the anterior structures, making it easier for the surgeon and the assistant.

A major pitfall to this exposure is when the surgeon believes that the exposure is medial enough and begins the osteotomy only to discover that it extends into the anteromedial acetabulum. It is important that the pectineal tubercle is identified and that the pectineus muscle is reflected off it. The osteotomy should be medial to this pectineal tubercle. As with the ischial cut, a curved forceps or retractor is passed around the pubic ramus superiorly and out of the obturator foramen inferiorly while staying in contact with the bone. The osteotome is directed medially to cut the pubic ramus. A rongeur can also be used to create the osteotomy.

A



B

FIGURE 23-89. A,B: There now remains only one of the three osteotomies, that of the iliac bone. This is accomplished exactly as described for the Salter osteotomy.

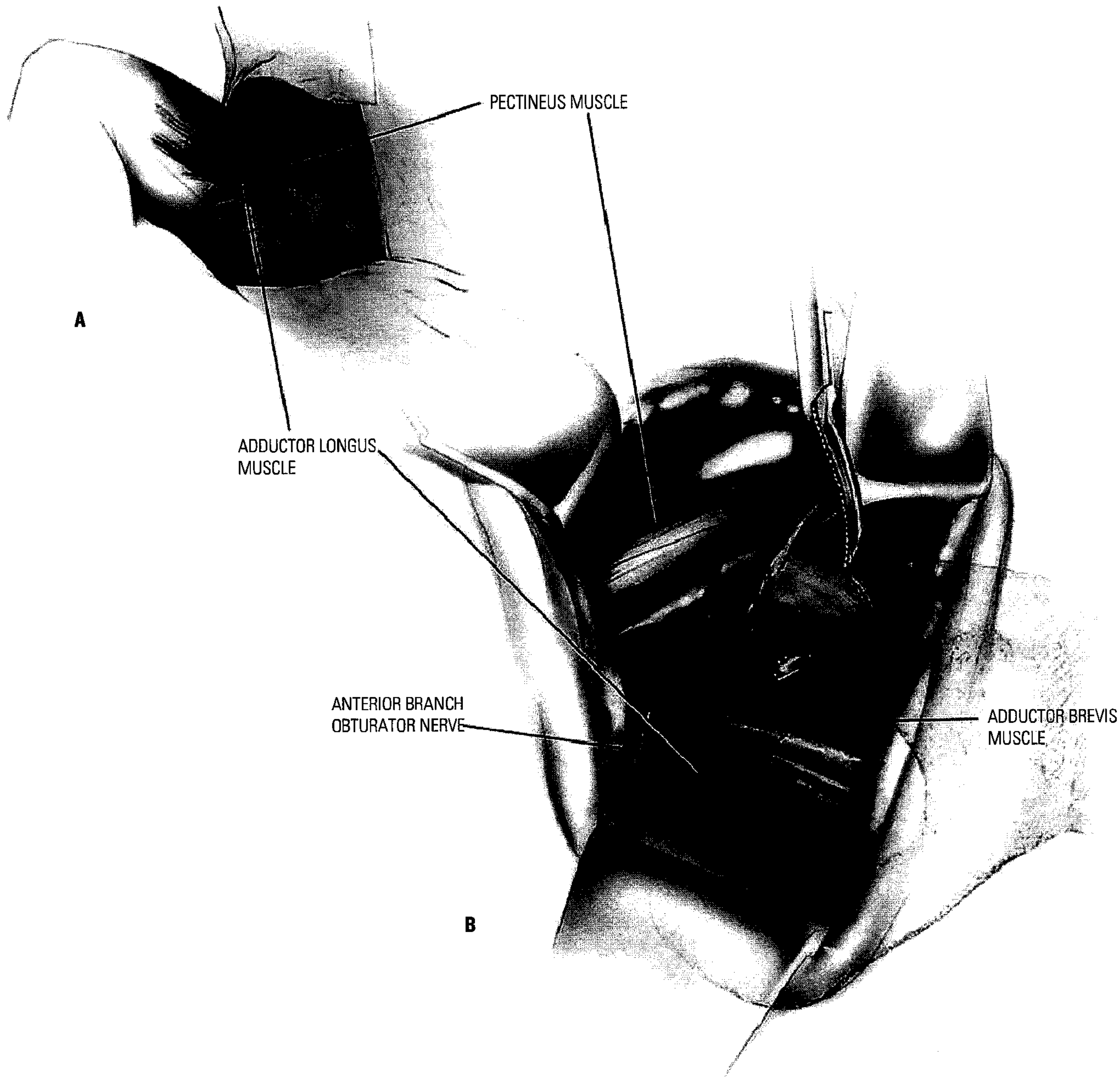


FIGURE 23-90. An alternative exposure to divide the pubic and ischial rami is through a groin approach. The incision is transverse. It is placed about 1 cm from the groin crease **(A)**, starting 2 cm anterior to the adductor longus tendon and extending back to the posterior border of the gracilis muscle. The adductor longus tendon is isolated and retracted posteriorly. The pectineus muscle, which lies superior to the adductor longus tendon, is identified, and its border is dissected free up to its insertion on the pubis. The anterior branch of the obturator nerve lies deep in this interval, between the adductor longus and the pectineus, and should be protected. The femoral vessels and nerve lie just lateral to the pectineus muscle. This approach places the surgeon medial to the pectineal tubercle without strenuous retraction, as is needed when this area is approached from the transverse iliac incision. At this point, a subperiosteal dissection of the pubic ramus is accomplished. A suitable curved forceps, retractor, or elevator is placed around the back side of the pubic ramus after the periosteum and obturator muscle origins are elevated **(B)**. An osteotome cutting toward the protecting forceps completes the osteotomy.

FIGURE 23-91. The next part of the exposure is similar to that for proximal hamstring release, but it must be accomplished through a wider exposure. The gracilis is separated from the crural fascia, and its posterior border is identified. The adductor magnus muscle lies deep and anterior to this posterior border. The interval between the posterior border of the gracilis and the adductor magnus muscles anteriorly and the proximal insertion of the hamstrings posteriorly is opened. It requires sharp dissection to open this interval sufficiently.

After the insertion of the hamstrings into the ischium is visualized, exposure is carried superiorly along the ramus of the ischium. At this point, the periosteum is incised and elevated. A forceps is passed around the ischium to protect the structures beneath, and an osteotome is used to divide the ischial ramus.

FIGURE 23-92. With the acetabular fragment completely mobile, the fragment is grasped with a large towel clip in the same manner as for a Salter osteotomy. Another technique is to insert a large threaded Steinmann pin or Schanz screw into the distal fragment parallel to the osteotomy to use as a joystick. It should be possible to rotate it freely as far anteriorly and laterally as desired. Care should be taken to gain only the correct amount of coverage because excessive rotation, especially anteriorly, could create impingement. Unlike the Salter osteotomy, a lamina spreader can be used to separate the osteotomy in the iliac bone. This is because the fragment is free and does not exert excessive upward pressure on the sacroiliac joint. When the desired correction is obtained, a bone graft from the anterior crest of the ilium is fashioned to fit in the gap in the iliac osteotomy. Fixation of the osteotomy and graft ideally are done with 7-mm cannulated screws. One or two are passed from the cephalad to caudal direction, as in the Salter osteotomy, and another from the caudal direction, near the acetabular edge of the distal fragment, in the proximal direction. The osteotomy of the ischium and the pubis is not fixed. The wound is closed, and a drain is used at the surgeon's discretion.

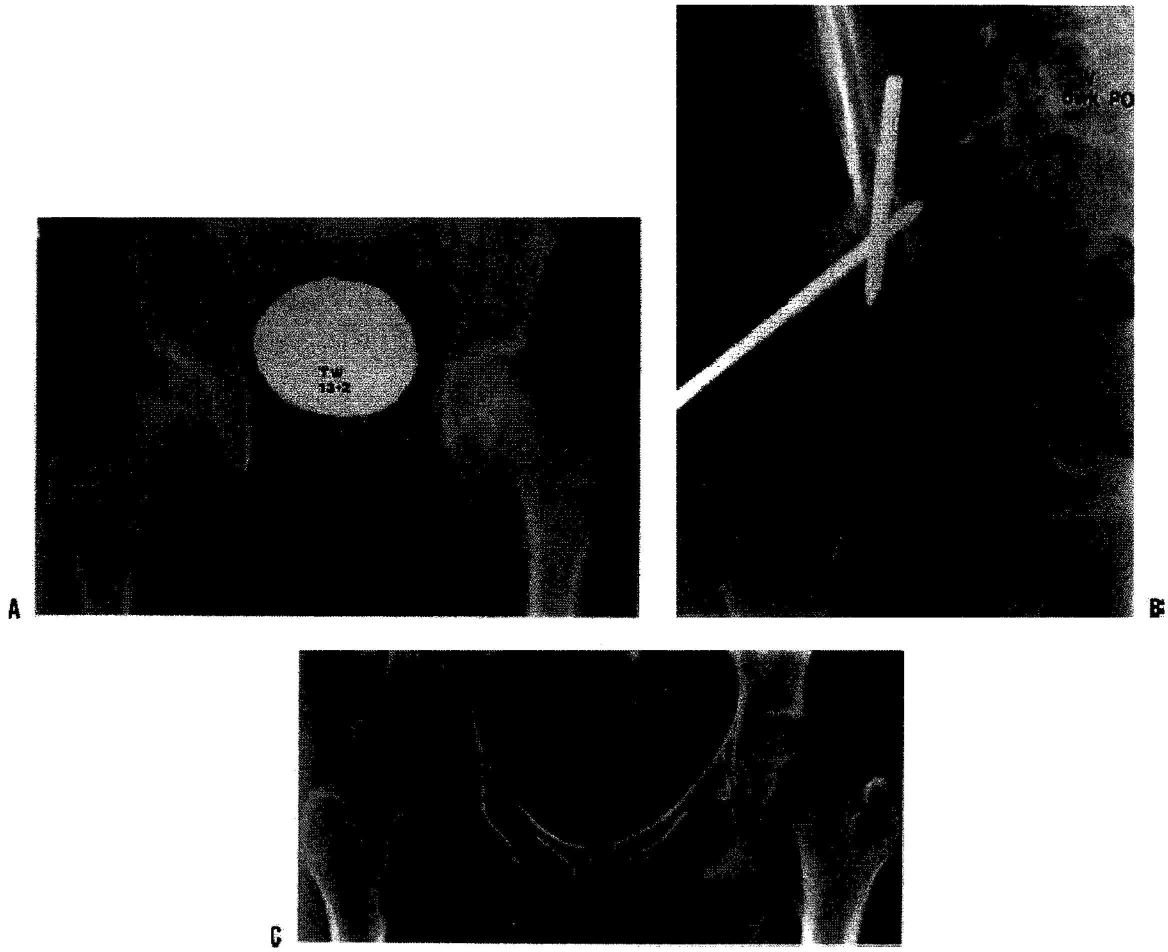


FIGURE 23-93. TW is a 13-year, 2-month-old girl who presented with a history of 6 months of increasing right hip pain. She was treated for congenital dislocation of the right hip at 3 months of age with a closed reduction. She has type II avascular necrosis **(A)** and acetabular dysplasia of the right hip. She was treated with a triple-innominate osteotomy fixed with two 5/32-inch threaded pins. **B:** We now use the 7-mm cannulated screws. They are stronger, can be removed percutaneously with radiographic control, or can be left buried. Five years postoperatively **(C)**, the patient remains symptom free, with good radiographic coverage of the hip.

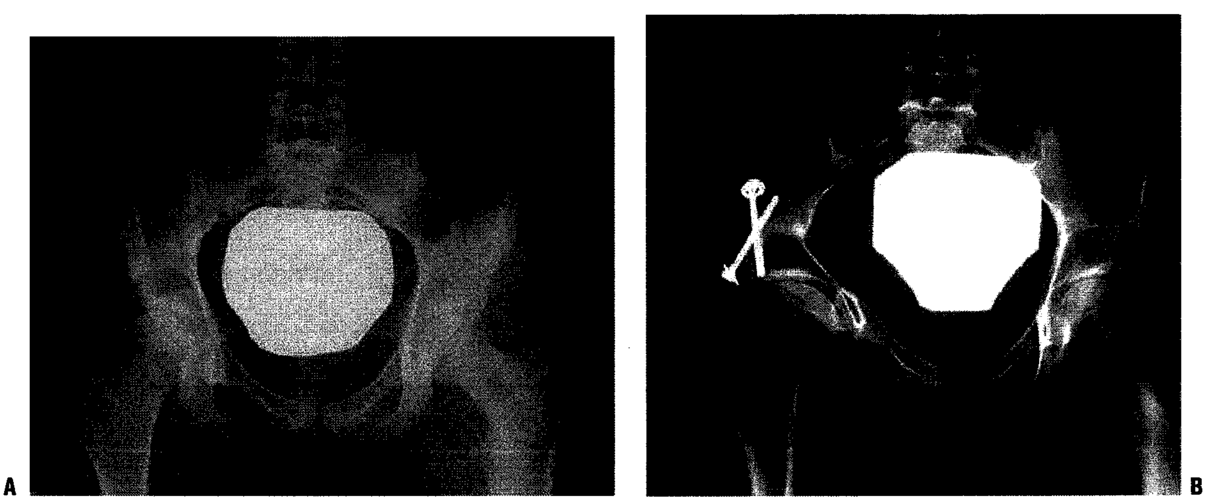


FIGURE 23-94. A 16-year-old patient with residual dysplasia after treatment for developmental dislocation of the hip (DDH) and pain. **A:** Preoperative anteroposterior radiograph. **B:** Anteroposterior radiograph 2 years after a triple-innominate osteotomy.

periacetabular osteotomy (GPAO) (455) offers an extremely powerful and versatile technique for reorientation of the mature dysplastic acetabulum (Figs. 23-95 to 23-101). It is among the latest of a series of pelvic osteotomies that have been developed to allow more extensive corrections than are routinely achievable by simple innominate osteotomy in the adolescent and young adult hip. Alternatives to the Bernese (Ganz) osteotomy include the triple-innominate osteotomy of Tonnis (422) and the spherical rotational osteotomies developed independently in Europe by Wagner (437, 438) and in Japan by Ninomiya and Tagawa (456).

The best indication for any acetabular realigning osteotomy is a spherically congruous dysplastic hip with effective malorientation of the acetabulum and minimal osteoarthritic changes.

The PAO has certain distinct advantages over the triple osteotomy and the spherical osteotomy. It can be performed through a single anterior incision through an abductor sparing approach (457–459). The acetabular osteotomy fragment is large enough to have sufficient vascularity to permit simultaneous arthrotomy to carry out labral debridement and other intraarticular work. The fragment is also large enough to allow robust internal fixation with multiple screws, permitting early partial weight bearing with crutches and no external immobilization. The PAO lines are close enough to the acetabulum to permit preservation of the posterior column and thereby good intrinsic stability of the pelvis.

Postoperative Care. Postoperatively, routine deep-venous thrombosis prophylaxis is maintained for 6 weeks in patients over 15 years of age. Postoperative ambulation is begun 48 to 72 hours after surgery, once the drains have been removed. The patient is maintained at one-sixth body weight bearing on the operative limb with crutches or a walker for 6 to 8 weeks. If adequate bone healing has occurred, an increase in weight bearing is allowed. No antigravity exercises are allowed for 2 months following surgery. Screw removal is considered 4 to 6 months following surgery.

A recent mean 20-year follow-up has been published by the developer of the procedure (460). Clohissy et al. in a systematic literature review of the PAO stated that although the use of the PAO in symptomatic acetabular dysplasia is to relieve pain and improve function; "the strength of the evidence to support this procedure for these goals is not well defined in the literature." With Level IV evidence, the authors showed that the PAO provides pain relief and improved hip function over the short- to mid-term follow-up; Major complications occurred in 6–37% of cases. As with all acetabular procedures, only longer term follow-ups will determine if degenerative joint disease can be prevented (241).

The second group among the treatment options includes acetabuloplasties that involve incomplete cuts and hinge on different aspects of the triradiate cartilage, such as the acetabular procedures described by Pemberton (40, 344, 346, 365, 367–369, 461–463) and Dega (464–468). These procedures can theoretically decrease the volume of the acetabulum because they depend on the triradiate cartilage as the fulcrum, although a recent paper disputes this assumption (469).

An increasingly popular innominate osteotomy is the Pemberton osteotomy. Pemberton developed the pericapsular osteotomy to address (Figs. 23-102 to 23-105) two problems that he saw in the older child with subluxation or dislocation of the hip. First, the acetabulum was not only "shallow" but also facing forward and laterally. Second, in the dislocating hip, the femoral head was usually small in relation to the acetabulum, whereas in the subluxating hip the acetabulum was large relative to the femoral head. The osteotomy was designed to hinge in the acetabulum through the flexible triradiate cartilage. Pemberton also observed that the direction of coverage obtained could be varied, depending on the direction of the osteotomy of the ilium (40).

The eclectic surgeon recognizes the value of this procedure in the treatment of the subluxating or dislocated hip with an acetabulum that is relatively large in relation to the femoral head, such as the subluxating hip or in some of the neurogenic dislocating hips. At the same time, this can be a disadvantage if there is not a relative size discrepancy between the acetabulum and femoral head. The ability to vary the direction of the coverage is an additional advantage, especially when more lateral than anterior coverage is desired. A final advantage is that the bone graft is stable without additional pins, obviating the need for subsequent pin removal.

The prerequisites for the operation include a concentric reduction of the hip and triradiate cartilage that is open to the extent that it is made sufficiently mobile. In normal children, the triradiate cartilage is sufficiently mobile until 7 or 8 years of age. In children with severe cerebral palsy or myelomeningocele, in whom this is often a useful operation, mobility in the triradiate cartilage can be present until 10 years of age or later.

A combination of the Pemberton and Salter osteotomies has also been described—the Pember-Sal osteotomy (470). The osteotomy continues past the triradiate cartilage into the body of the ischium; it does not break through into the sciatic notch. A Pember-Sal osteotomy is used most often and incorrectly to describe an osteotomy that has not stayed within the ilium but rather has broken into the sciatic notch before reaching the triradiate cartilage.

As in all acetabular redirections, the matter of incongruity must be considered. Although minor degrees of incongruity between the acetabulum and the femoral head will remodel, the extent of this process depends on the child's age. To produce the best results, it is probably wise to apply the criteria that Salter uses for his innominate osteotomy. The patient is placed in the same position as for open reduction of the hip joint through the anterior approach, and the same incision and approach are used.

Postoperatively, because of the usual young age at which this osteotomy is performed, the patient is immobilized in a single-leg spica cast. The length of immobilization depends on the other procedures done, but 6 weeks of immobilization is usually sufficient to allow protected weight bearing and physical therapy to regain motion.

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Ganz Periacetabular Osteotomy (Figs. 23-95 to 23-101)

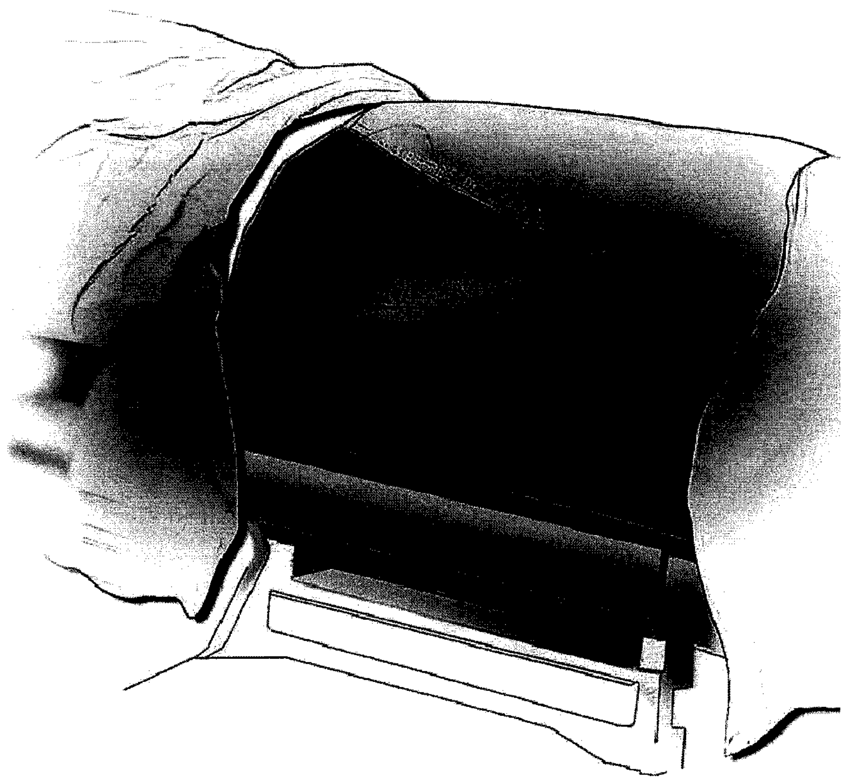
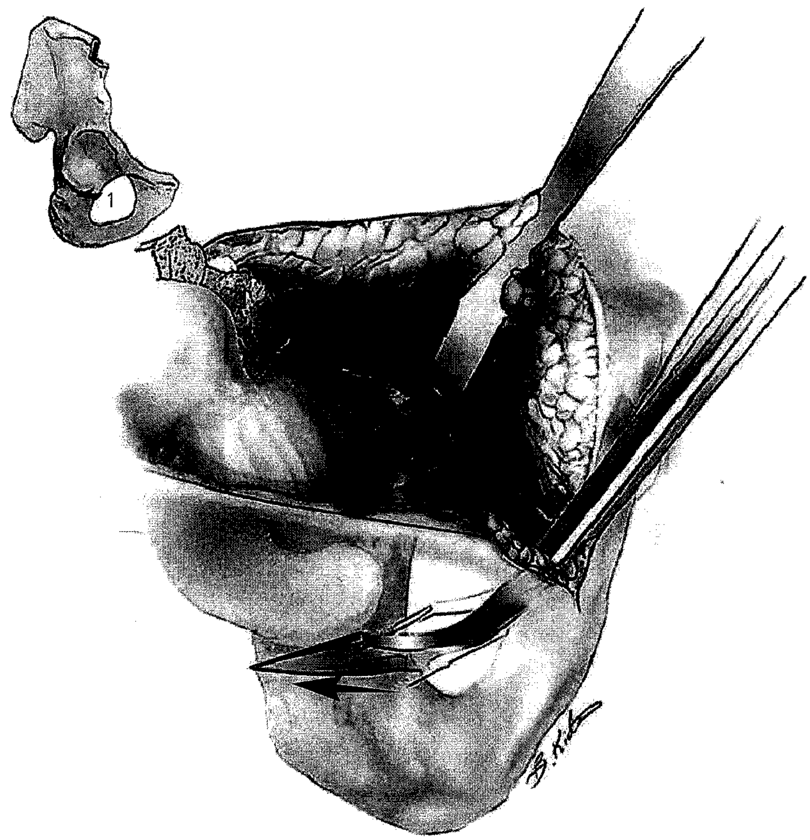


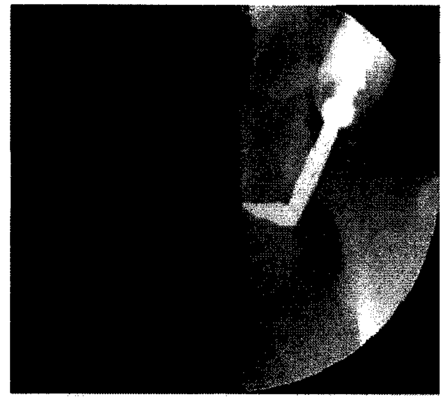
FIGURE 23-95. Ganz Periacetabular Osteotomy. The patient is positioned supine on a radiolucent table with the ipsilateral leg draped free. Several options exist for the skin incision. The classic Smith-Petersen incision, which is convex anteriorly, is extensile but often heals with a wide scar. A bikini-type incision centered just distal and lateral to the anterior superior iliac spine (ASIS) is much more cosmetic but more difficult to work through, particularly for large or muscular patients.

Variations in the deeper soft-tissue exposure are also possible. For the surgeon less familiar with the PAO, the Smith-Petersen exposure, which exposes both the medial and lateral walls of the ilium subperiosteally, allows better visualization of the iliac and posterior column osteotomies on the internal and external walls. For the more experienced surgeon, the abductor attachment to the iliac crest may be left undisturbed. Only a small subgluteal window made just distal to the iliac crest is needed laterally to allow the saw cut osteotomy of the supraacetabular ilium. The abductor-sparing direct anterior approach will be described here.

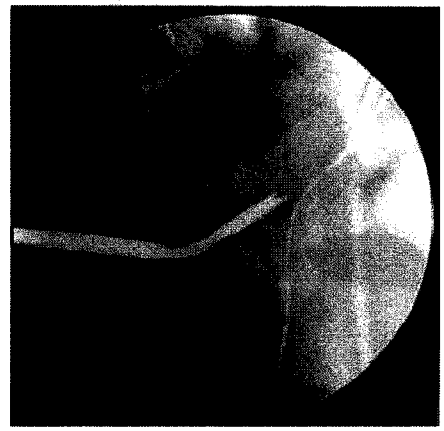
After the skin incision, the tensor fascia lata-sartorius interval is developed, staying lateral to protect the lateral femoral cutaneous nerve. Along the floor of this interval, the fascia over the rectus femoris is identified.

Next, the external and internal oblique muscles are reflected in a subperiosteal manner off the anterior half of the iliac crest. If the patient is skeletally mature, with no remaining iliac apophysis, it is useful to osteotomize a 1.5 cm × 1.5 cm block of ASIS bone along with the attachment of the sartorius and inguinal ligament, to allow secure reattachment of these structures with a screw. The inner pelvis is then exposed in a subperiosteal manner to the level of the pelvic brim.





A



B

FIGURE 23-96. The hip is then flexed and adducted, with the leg supported temporarily on a towel bump under the knee and thigh. The reflected head of the rectus femoris is divided over a right-angle clamp, which then allows the straight head of the rectus to be elevated sharply off the anterior inferior iliac spine (AIIS). The rectus muscle and the iliocapsularis are elevated sharply together off the hip capsule in a medial and distal direction. The psoas sheath is then opened longitudinally to allow the psoas tendon to be retracted medially, exposing the iliopectineal eminence. A spiked Hohmann retractor impacted into the superior ramus medial to the iliopectineal eminence will assist in the exposure. Large Mayo scissors can be used to further open the interval for the ischial cut between the capsule and psoas at the level of the infracotyloid groove. Confirmation with the image intensifier is useful at this step in both the anteroposterior **(A)** and faux profil **(B)** projections (9). Once sufficient space has been created between the psoas tendon and the medial capsule, the forked tip of the Ganz chisel is placed just distal to the hip capsule but within the infracotyloid groove of the ischium. The chisel tip must remain proximal to the obturator externus tendon that lies in the groove, since the major medial femoral circumflex artery branch lies just distal to the tendon. The chisel is then impacted into the ischium to a depth of approximately 2 cm. The blade is held perpendicular to the long axis of the body and directed in an anterior to posterior direction. The medial cortex must be divided. The softer lateral cortex need not be divided, and indeed it may be hazardous to extend the osteotomy chisel beyond the lateral cortex because of the proximity of the sciatic nerve at this level.

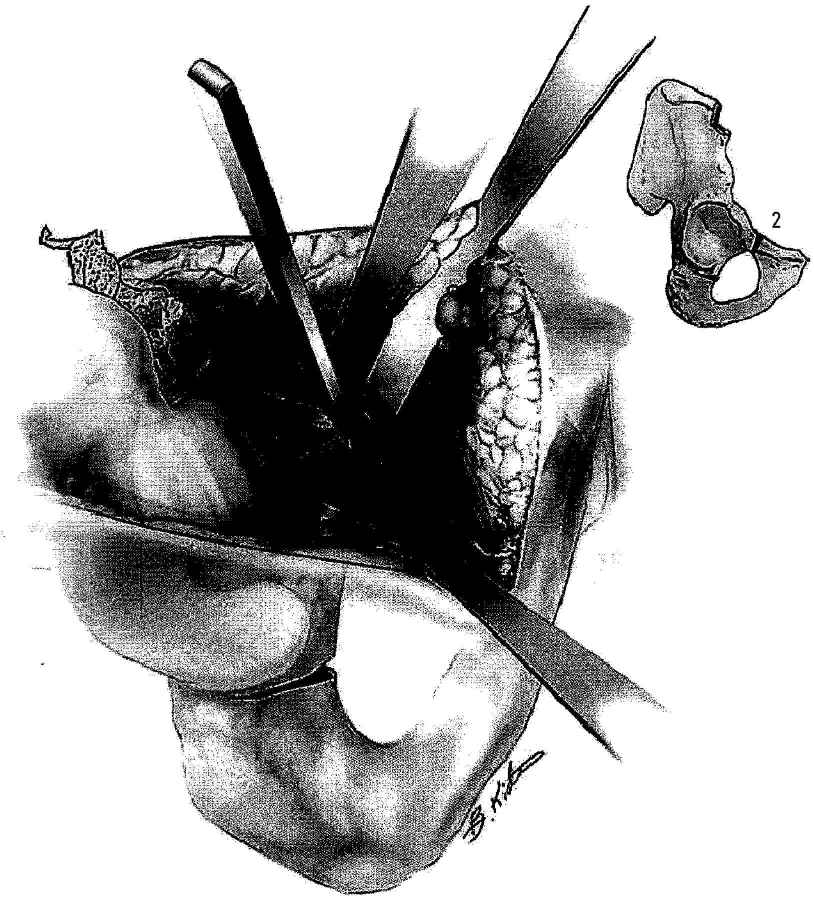


FIGURE 23-97. The next osteotomy is of the superior pubic ramus. The flexed leg is now adducted and the subperiosteal dissection along the ramus is continued even more medially. The sharp Hohmann is again impacted to aid in retraction of the psoas and neurovascular bundles. Medial to the iliopectineal eminence, the superior pubic ramus is dissected in a subperiosteal fashion and curved Lane retractors are placed into the obturator foramen around the ramus. A straight osteotome is then used to perform the osteotomy with the retractors providing soft-tissue protection. The osteotomy begins medial to the iliopectineal eminence and is angled approximately 45 degrees from anterolateral to posteromedial, as well as being angled from distal–lateral to proximal–medial. The osteotomy can occasionally be incomplete posteriorly, which will greatly impede fragment rotation later; consequently, ensuring that the osteotomy is complete at this point is important. Performing this osteotomy with a Gigli saw passed through the obturator foramen is an alternative method. If an arthrotomy of the hip is to be carried out, it should be done at this point. A radial arthrotomy or a T-shaped incision can be used. The femoral head, labrum, and rim can be inspected and any intraarticular pathology treated. The capsule can be closed at this point or left open to allow direct visualization to rule out impingement after acetabular rotation has taken place. At this point, the deep medial dissection of the pelvis is continued over the pelvic brim toward the ischial spine, completely freeing the quadrilateral plate. A blunt Hohmann retractor is placed on the ischial spine, and palpation of the sciatic notch is not necessary.

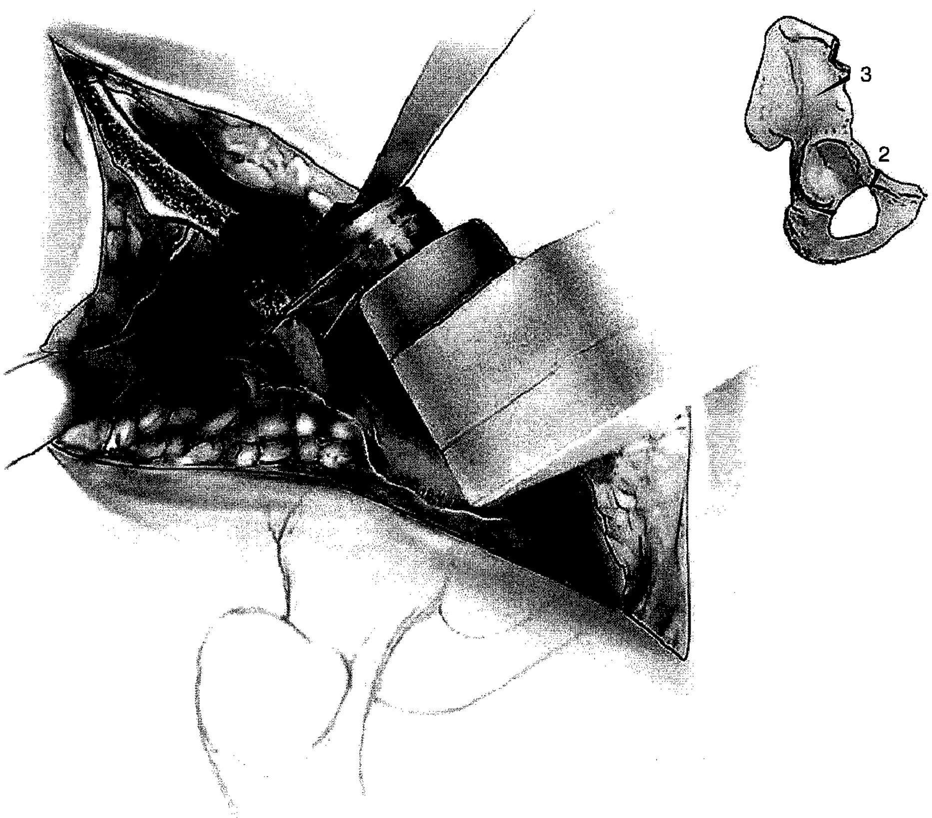


FIGURE 23-98. A small subperiosteal tunnel is made along the lateral wall of the ilium just distal to the ASIS osteotomy, without disturbing the abductor origin. This tunnel stops well short of the sciatic notch. A narrow-spiked Hohmann retractor is placed gently within the tunnel to protect the abductors during the ensuing iliac osteotomy made with the oscillating saw. The iliac osteotomy is usually vertical, beginning at the ASIS level and directed posteriorly, in the direction of the apex of the sciatic notch. The saw cut stops about 1 cm anterior to the iliopectineal line.

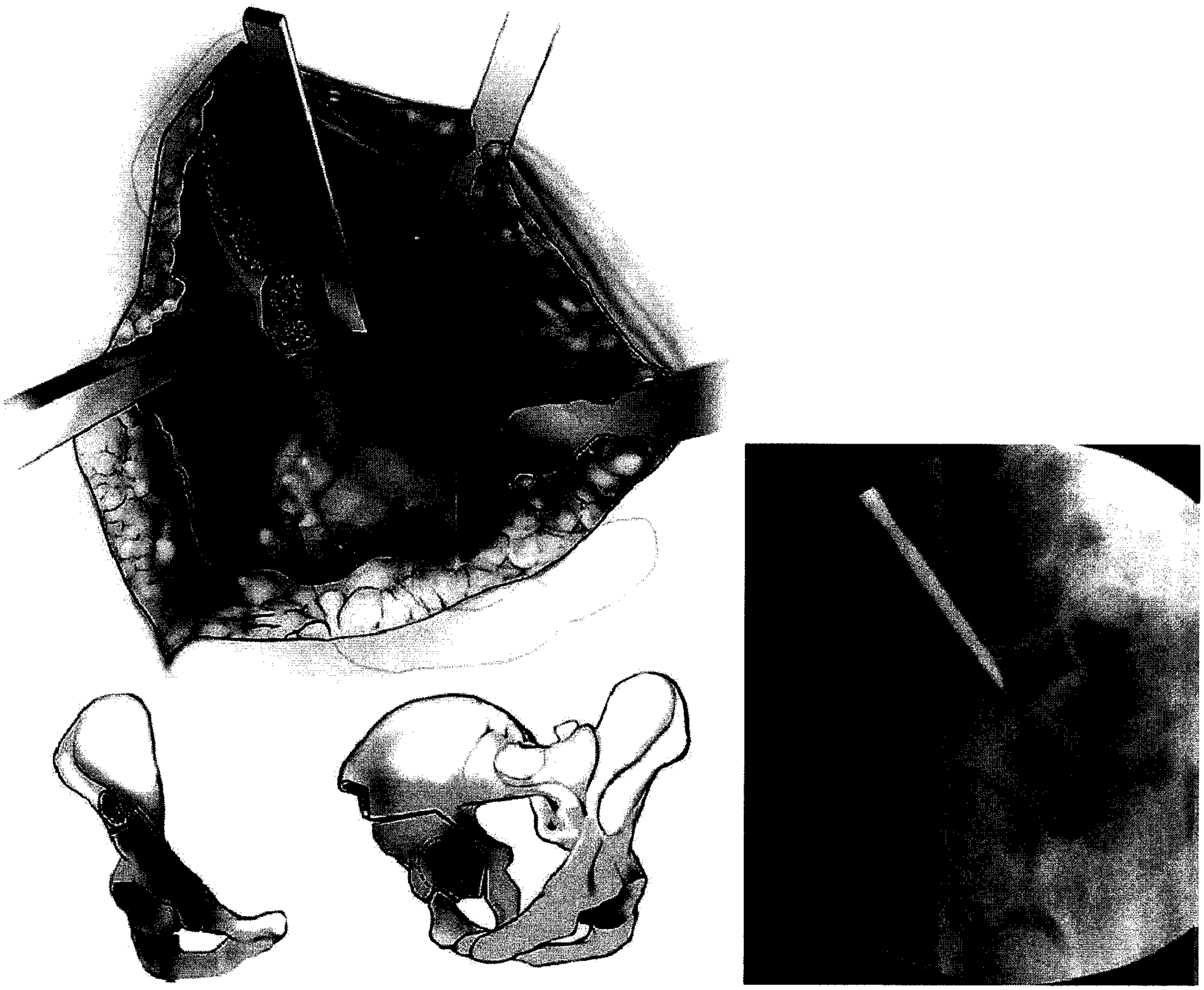


FIGURE 23-99. The posterior column osteotomy is performed with the hip nearly fully extended, to relax the nearby sciatic nerve. It is made with a straight chisel, beginning on the medial surface of the ilium, at the posterior end of the saw cut. This osteotomy is directed at the ischial spine, at an angle of about 120 degrees with the iliac saw cut. Image intensifier control in the faux profil projection allows visualization of the distance of this osteotomy line from the acetabulum as it bisects the posterior column between the posterior acetabulum and the sciatic notch (see inset).

After the medial cortex is divided to a point at least 4 cm below the iliopectineal line, the proximal lateral cortex can be carefully divided with a chisel, as a bone spreader distracts the iliac osteotomy, stressing the remaining bone bridges. The deeper lateral cortex will usually fracture spontaneously.

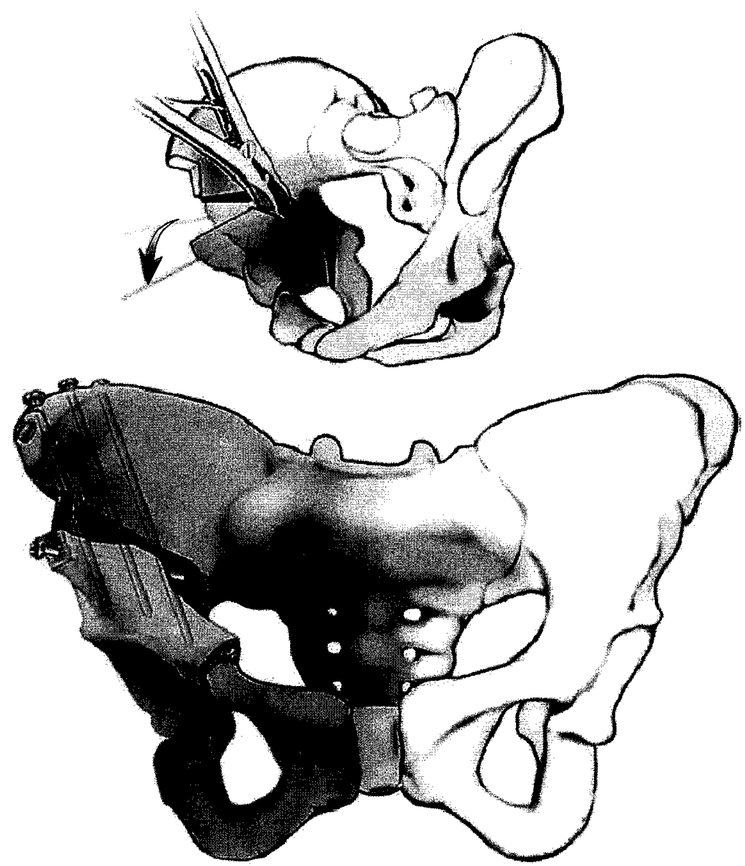


FIGURE 23-100. The acetabular fragment should have considerable mobility at this point. The remaining deep medial bone bridge is usually no more than about 2cm in length. To complete mobilization of the fragment, a Schanz screw is inserted in the anteroposterior direction in the region of the AIIS. Using a T-handle chuck and lamina spreaders through the anterior portion of the iliac osteotomy, the remaining bone bridge will fracture. If the fragment is not mobilized adequately with this maneuver, further patient division of the remaining bone bridge may be carried out with the angled Ganz chisel. It is important to make sure that the chisel is at least 4cm below the pelvic brim in order to avoid an intraarticular osteotomy. Once the fragment is mobile, it is redirected with the assistance of some or all of the following instruments: the Schanz screw in the T-handled chuck used as a joy stick, bone spreaders in the iliac and posterior column osteotomies, a ball spike, and a Weber bone clamp applied to the medial anterior portion of the acetabular fragment just lateral to the superior pubic ramus osteotomy. The usual correction maneuver involves anterior rotation of the acetabulum in the axis of the ilium, which improves both anterior and lateral coverage. Occasionally, lateral rotation is required as well, as is medial rotation to avoid retroversion.

After the desired amount of correction is achieved, two or three provisional k-wires are placed through the iliac crest into the acetabular fragment. A plain anteroposterior radiograph is then taken to confirm proper fragment positioning. It is important to assess not only that the weight-bearing zone is horizontal or near-horizontal but also the congruity of the hip joint, the version of the acetabulum, the extent of medialization or lateralization, and Shenton line.

Once a satisfactory radiographic alignment has been confirmed, it is mandatory to rule out impingement by carrying out passive flexion and abduction. Ninety degrees of impingement-free flexion is desirable. The capsulotomy is closed at this point, if it has not already been closed, and the fragment is secured with a minimum of three screws. Typically, these are placed along the iliac crest, but the anterior to posterior "home run" screw drilled from the AIIS into the posterior column above the apex of the sciatic notch gives an additional degree of fixation, although this screw is more difficult to retrieve if postoperative hardware removal is carried out.

Any protruding bony pieces are trimmed and used as local bone graft. The straight head of the rectus is secured through the hole left by the Schanz screw, giving a strong transosseous repair. If performed, the ASIS osteotomy is secured with a screw. Drains are routinely used along the medial pelvis. The periosteum and abdominal wall musculature is secured through drill holes to the iliac crest.

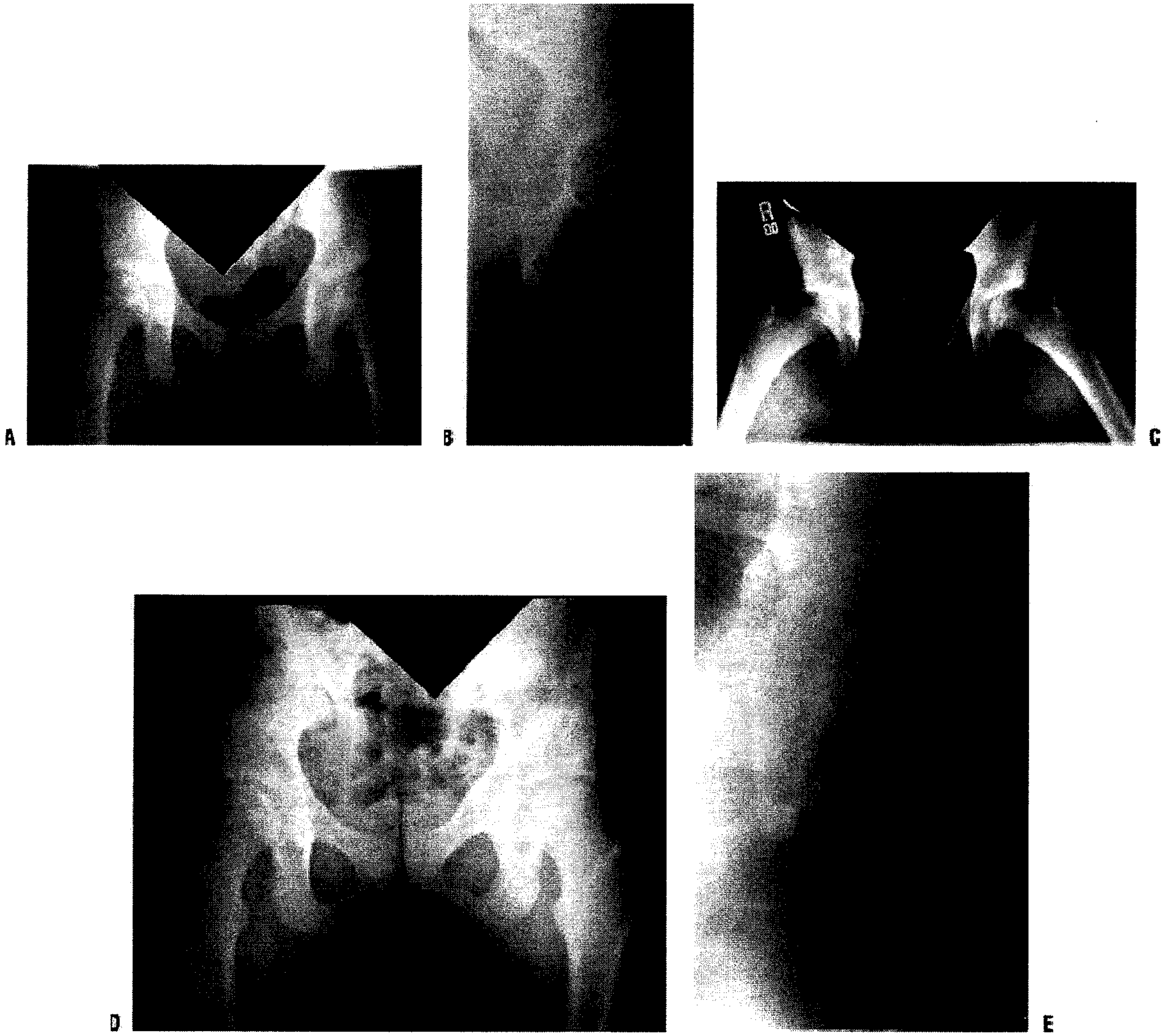


FIGURE 23-101. This 15-year-old female figure skater presented with a 1-year history of progressive anterolateral left hip pain. **A–C:** Anteroposterior, faux profil, and von Rosen views show left hip dysplasia with decreased anterior and lateral center-edge angles and an upsloping sourcil. Also, note the acetabular rim fracture. **D, E:** The anteroposterior and faux profil views 2 years after PAO on the left hip with subsequent hardware removal. The rim fracture has healed, anterior and lateral center-edge angles have improved, the sourcil is horizontal, and her symptoms have resolved.

The Dega osteotomy (Figs. 23-106 to 23-109) is another popular innominate osteotomy used in young children in conjunction with open reduction or alone to correct residual acetabular dysplasia. There has been significant confusion in the literature as to what specifically is a Dega osteotomy.

Dega developed his osteotomy in the treatment of DDH to fill the need for anterolateral coverage. In concept, the Dega osteotomy is more like the Pemberton osteotomy than any other osteotomy: it is an incomplete pelvic osteotomy, it alters the shape of the acetabulum, it has a posterior hinge, it can provide a variable amount of anterolateral coverage, and it cannot increase the posterior coverage sufficiently because that is where the hinge remains. Whereas the Pemberton osteotomy ends in the ilioischial limb of the triradiate cartilage and completely divides the iliac bone from anterior to this point, the Dega osteotomy ends just above the horizontal portion of the triradiate cartilage (the ilioischial and iliopubic portions) and leaves a posterior portion of both the inner and outer iliac cortex just anterior to the sciatic notch intact, forming its hinge.

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Pericapsular Iliac Osteotomy of Pemberton (Figs. 23-102 to 23-105)

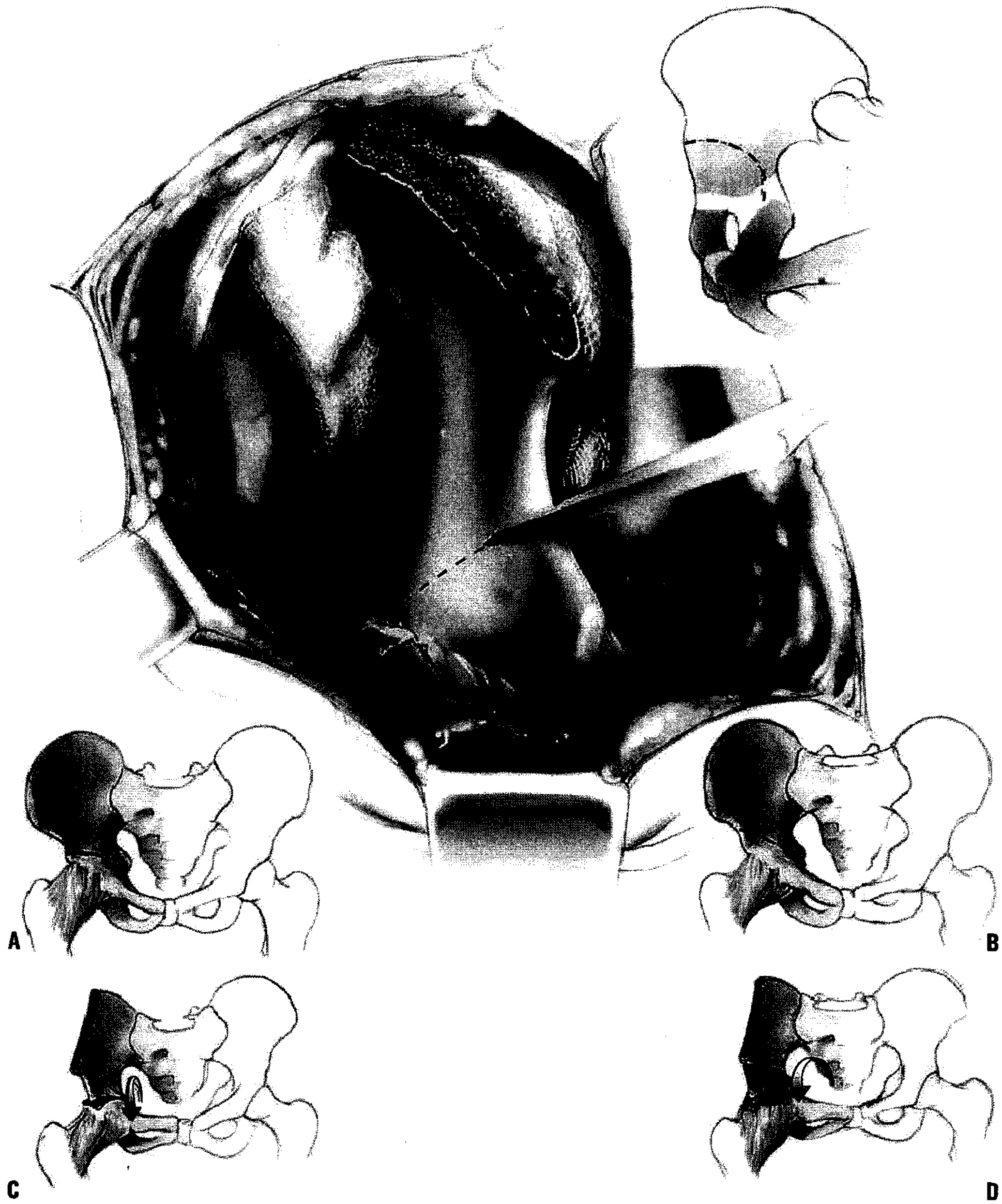

FIGURE 23-102. Pericapsular Iliac Osteotomy of Pemberton. After the iliac apophysis is split, the inner and outer tables of the ilium are exposed subperiosteally, which is sufficient to expose the sciatic notch on both sides. It is not necessary to expose the capsule of the hip joint unless an open reduction is performed at the same time. Likewise, it is not necessary to divide the combined head of the rectus femoris muscle. Although Pemberton did not recommend division of the psoas tendon, it may be advisable to do this, as in Salter innominate osteotomy. The osteotomy is planned based on the direction in which coverage is needed. If more anterior coverage is desired **(A)**, the plane of the osteotomy is more transverse. If lateral coverage is desired **(B)**, the plane of the osteotomy is inclined more laterally. After this is determined **(C)**, a small, osteotome can be used to outline the osteotomy by cutting the cortex of the inner and outer table. The osteotomy is begun about 1 cm above the anteroinferior iliac spine and proceeds posteriorly, keeping about 1 to 1.5 cm away from the attachment of the joint capsule. As the osteotome proceeds posteriorly and then inferiorly through the outer table, it disappears from sight in the soft-tissue attachments behind the posterior aspect of the capsule, and there is a strong tendency for the osteotome to cut into the sciatic notch. Care in exposing the sciatic notch as far inferiorly as possible makes this error easier to avoid by seeing the portion of the ilium that lies between the sciatic notch posteriorly and the capsule of the hip joint anteriorly. It is neither possible, necessary, nor advisable, however, to expose this down to the triradiate cartilage. The same problem exists when cutting the cortex of the inner table, but not to the same extent. No capsule is present **(D)**; therefore, it is sufficient to stay slightly anterior to the sciatic notch. A cobra retractor can be placed in the sciatic notch. By twisting it, the tissue is retracted, giving good exposure to the posterior area distal to the sciatic notch where visualization is most difficult.

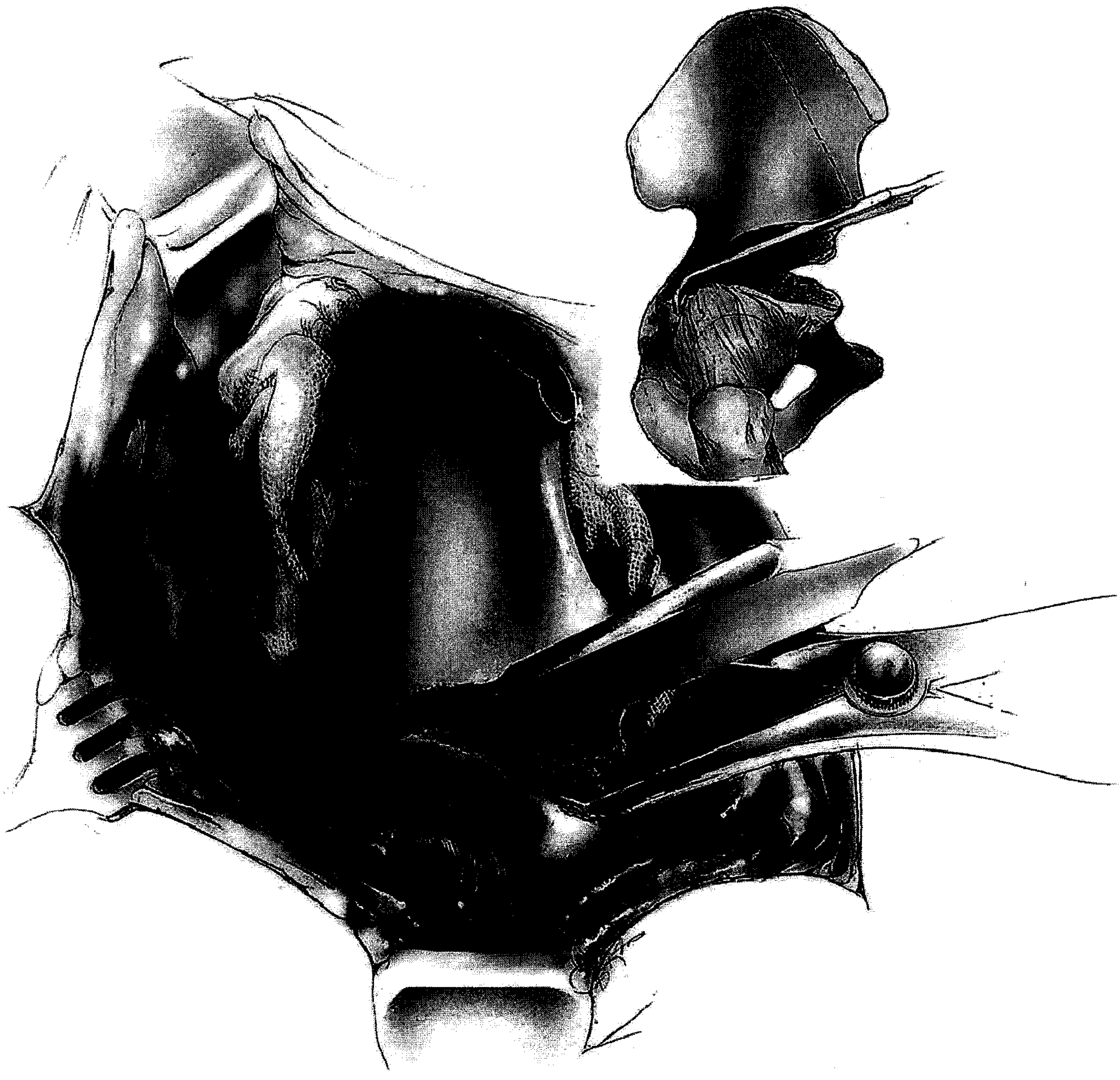

FIGURE 23-103. After the inner and outer cortices of the ilium are divided as far as can be seen, a wider curved osteotome is used to connect these two cuts. As the osteotome proceeds posteriorly, it becomes apparent that it is not able to make the sharp turn inferiorly to avoid cutting into the sciatic notch. At this point, an osteotome with a right-angled curve is inserted into the osteotomy. This can be made easier by prying down on the acetabular roof with an osteotome and inserting a small lamina spreader to hold the osteotomy apart. The special osteotome is used to complete the cut into the triradiate cartilage. It is not possible to see the tip of the osteotome as it completes the osteotomy. It is not necessary and usually not possible to see the triradiate cartilage unless the acetabulum is levered down excessively. Fluoroscopic imaging is helpful at this point in the procedure. When the osteotomy is complete, the acetabular roof can be levered down into the desired position and held there with a lamina spreader.

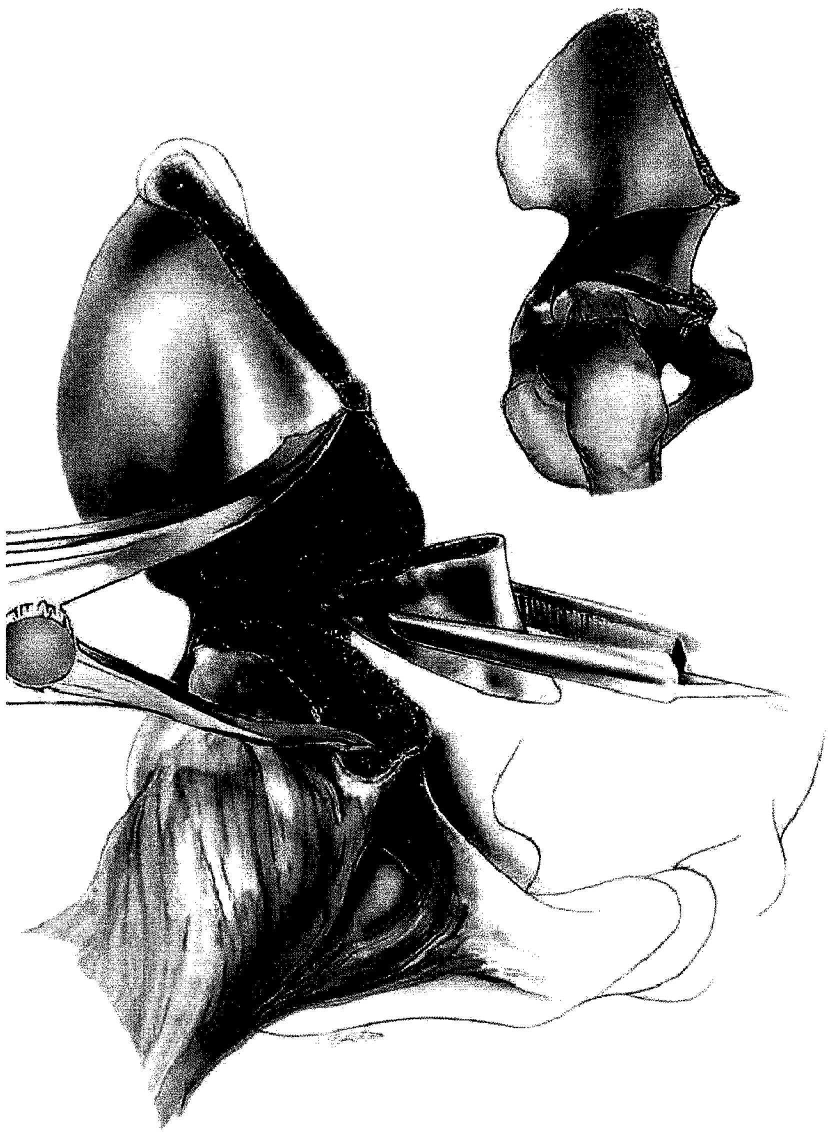

FIGURE 23-104. Grooves are prepared in the cancellous surface on each side of the osteotomy to provide secure fixation of the bone graft. This can be done with a curette. A triangular wedge of bone is cut from the anterior iliac crest. It should be larger than the gap it is designed to span because it will be recessed into the cancellous bone. When femoral shortening accompanies the procedure, the resected femur may be used as the source of the bone graft. When in place, the bone graft should be secure and stable, and this can be verified by attempting to dislodge the graft. The wound is closed in a routine manner.