Surgical Technique: Modified Bernese Triple Innominate Osteotomy

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Abstract

The triple innominate osteotomy is a complete redirectional acetabular osteotomy, consisting of cuts through the ilium, ischium, and pubis. This osteotomy spares the triradiate cartilage and allows the acetabulum to be completely freed from the rest of the pelvis which in turn allows the surgeon to obtain large corrections and control the final position of the acetabulum in multiple planes. This procedure is best indicated for skeletally immature patients with congruent or near-congruent joints that require large degrees of correction and/or changes in acetabular version. The modified Bernese triple osteotomy is performed through two incisions. The medial approach allows access for the ischial osteotomy which is oriented toward the proximal aspect of the ischial spine. The pubis is cut with a Gigli saw and is accessed through the interval between the rectus femoris and iliacus. The ilium is osteotomized in a modified manner from the typical Salter osteotomy. Once mobilized, the acetabulum is carefully positioned with the help of a Schanz screw and pointed tenaculum before definitive fixation is achieved with long 3.5 mm pelvic screws.

Introduction

The triple innominate pelvic osteotomy is indicated for the school-aged child or young adolescent with acetabular dysplasia who is still

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skeletally immature. First described by Le Coeur and later popularized by Steel and Tönnis, the triple innominate osteotomy involves complete cuts in the ilium, ischium, and pubis that spare the triradiate cartilage (unlike the Ganz periacetabular osteotomy which crosses the triradiate growth center) [1–3]. By doing so, the acetabulum is completely freed from the rest of the pelvis, which allows the surgeon to obtain large corrections and control the final position of the acetabulum in multiple planes. The triple osteotomy is a true redirectional pelvic osteotomy; unlike reshaping procedures like the Pemberton or the Dega, it does not change the size or shape of the acetabulum but does reorient the acetabulum in space [4]. Because the acetabulum is rotated around the femoral head to increase coverage, triple osteotomies require congruency or near congruency of the joint.

Triple osteotomies are best indicated in older children and adolescents with open triradiates who would not achieve sufficient correction from a Salter or Dega osteotomy, but whose acetabular growth potential may preclude a periacetabular osteotomy (which cuts directly through the triradiate cartilage). The exact age at which a PAO may be safely performed instead of a triple osteotomy is somewhat uncertain, but it is known that posttraumatic acetabular dysplasia occurs rarely after the age of 10 years, suggesting that the growth contribution of even an open physis is not significant at that age.

Triple osteotomies (similar to the PAO in the skeletally matured patient) are the osteotomies of choice for children in whom the surgeon wants to correct acetabular version or address dysplasia in the setting of a hypoplastic acetabulum. In this latter situation, a reshaping osteotomy would not improve lateral coverage but would only succeed in further reducing the volume of the acetabulum and placing excessive pressure on the femoral head [5]. In contrast, the triple osteotomy can reposition the existing sourcil (albeit short) more centrally over the weight-bearing zone, thereby improving coverage.

Planning and Positioning

After induction with general anesthesia, an epidural is typically placed for postoperative analgesia. Paralysis is avoided as both the sciatic nerve and obturator nerve are at risk during the procedure. The patient is then positioned supine on a radiolucent operating table. A bump is generally not used as it can distort intraoperative imaging. Both arms are positioned out laterally to facilitate access to the proximal pelvis by the surgeon (on the ipsilateral side) and the image intensifier (from contralateral side). Split drapes are used to allow access to the entire hemipelvis with care taken to place the posterior limb as posterior as possible to prevent draping out the ilium. In addition, the medial limb should be medial enough to allow access to the adductor region.

Medial Exposure and Ischial Cut

With the limb in a frog position, the first of two incisions needed to perform the modified Bernese triple osteotomy is made approximately 5 cm long, in line with the adductor longus muscle [6] (Fig. 1). The fascia is split in line with the skin incision, and the adductor longus tendon is isolated and retracted proximally to reveal the underlying adductor brevis (Fig. 2). The anterior branch of the obturator nerve must then be identified, mobilized, and traced proximally to the point at which it exits the pelvis through the obturator foramen. The anterior surface of the ischium lies just lateral to this point. A curved clamp is used to enlarge this opening along the lateral side of the nerve, and a lane retractor is passed through the foramen along the periosteum of the quadrilateral plate until it “hooks” on the ischial spine (Fig. 3). The image intensifier can be used with both anteroposterior (AP) and false profile views to confirm appropriate position of the lane. The lateral edge of the ischium should be palpated and a second lane passed around the edge in a similar trajectory as the first. Peanuts can now be used to

Fig. 1 Medial skin incision for ischial cut (Reproduced with permission from the Division of Orthopaedic Surgery, Children's Hospital of Philadelphia)

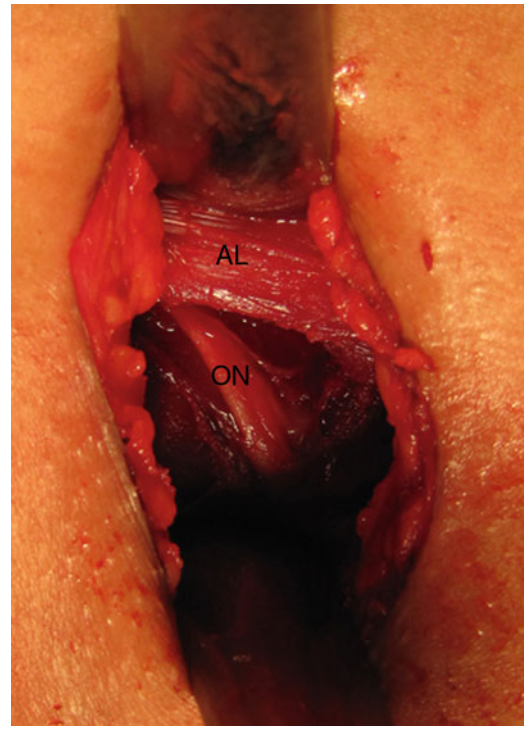

Fig. 2 The adductor longus tendon (*AL*) is identified and retracted proximally to reveal the underlying anterior branch of the obturator nerve (*ON*) (Reproduced with permission from the Division of Orthopaedic Surgery, Children's Hospital of Philadelphia)

clear fibers of the obturator externus as well as a leash of vessels off the periosteal surface of the ischium.

The correct starting point for the ischial cut is just inferior to the lip of the acetabulum; this can both be palpated and confirmed with the false profile view [6]. The cut should be aimed toward the proximal aspect of the ischial spine, as this negates the ability of the sacrospinous ligament to alter the mobility of the acetabular fragment (Fig. 4). A straight Ganz osteotome is used to make the osteotomy, starting on the medial side of the ischium followed by a second pass to cut the lateral side (Fig. 5). The position and depth of the cut can be periodically confirmed on the false profile view; throughout, the osteotome should be externally rotated such that the blade is on the "edge" on the image intensifier (Fig. 6). This results in a cut that is somewhat oblique in the coronal plane, angling from proximal medial to distal lateral. It is important that the medial lane retractor be kept in place during the medial cut to protect the contents of the sciatic notch. Similarly, the lateral lane retractor should be in place when cutting the lateral aspect of the ischium. Although use of these retractors obscures visualization on the image intensifier, the position of the osteotome can be confirmed by periodically withdrawing the lane (Fig. 7). Completion of the cut is confirmed by placing a Cobb in the osteotomy site and twisting to confirm fragment mobility. The wound is packed with a moist sponge in the event that the cut needs to be revisited.

Anterior Exposure and Pubis Cut

Similar to the exposure for an open reduction of the hip, an 8 cm incision is made parallel and 1–2 cm distal to the iliac crest, with approximately

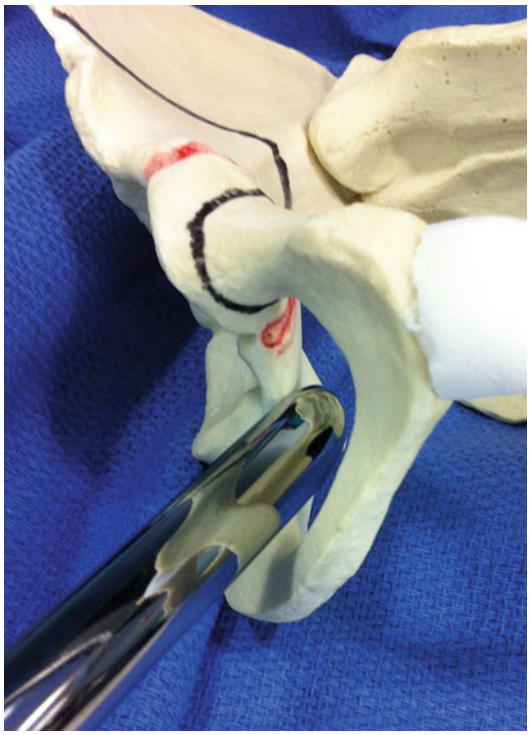

Fig. 3 The lane retractor is slid just lateral to the nerve through the obturator foramen along the quadrilateral plate until it "hooks" on the ischial spine (Reproduced with permission from the Division of Orthopaedic Surgery, Children's Hospital of Philadelphia)

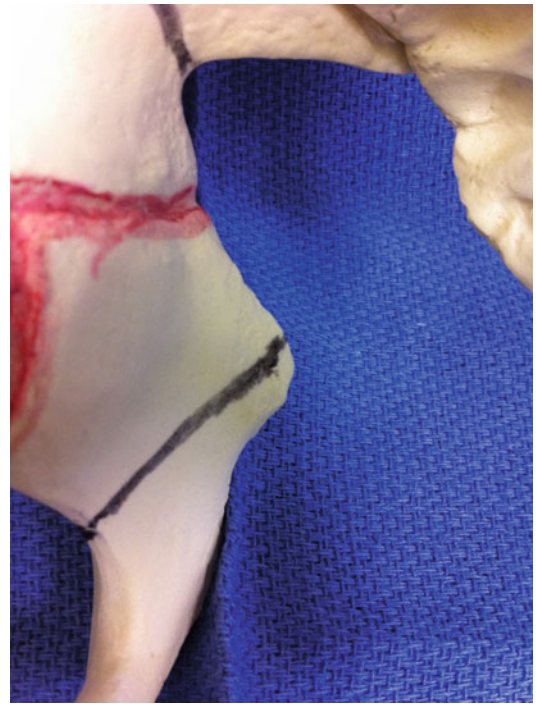

Fig. 4 The ischial cut is aimed toward the proximal aspect of the ischial spine (Reproduced with permission from the Division of Orthopaedic Surgery, Children's Hospital of Philadelphia)

3 cm of the incision extending medial to the anterior superior iliac spine (ASIS) (Fig. 8). The subcutaneous tissues are divided in line with the incision to expose the ilium; the overhanging external oblique muscle is feathered up and over the crest using bovie cautery.

Next, the Smith-Peterson interval is entered indirectly by incising the fascia overlying the tensor fascia lata muscle belly at approximately a 30° angle to the ASIS. The muscle can be separated from the medial compartment fascia and retracted laterally. One can then bluntly dissect down through the interval to the level of the rectus tendon. This indirect approach to the interval helps minimize risk of injury to the lateral femoral cutaneous nerve. Visualization of the direct head of the rectus itself can be improved by incising the thin fascia overlying the tendon.

Using a no. 15 blade scalpel, the iliac crest apophysis is then split down its midline from the ASIS to the point at which the crest begins to swing back medially (Fig. 9). Only the medial half of the apophysis is elevated with a Cobb or Freer elevator in a subperiosteal fashion down the inner table of the iliac wing. Minimizing exposure of the outer table helps preserve abductor function postoperatively. The iliac exposure and the Smith-Peterson interval are now connected by sharply dissecting along the prow of the ilium connecting the ASIS and the anterior inferior iliac spine (AIIS). In spite of the indirect access to the interval, care should still be taken at this point to protect the lateral femoral cutaneous nerve, which can cross the surgical field from medial proximal to distal lateral. If identified, the nerve should be mobilized and retracted medially.

The most bloodless interval with which to access the pubis is between the medial edge of the rectus tendon and the iliacus muscle (Fig. 10). The iliacus can sometimes adhere to the underlying periosteum, but lifting up and away with a Hibbs or Aufranc retractor can help clearly define

Fig. 5 A straight Ganz osteotome is used to make the ischial osteotomy, starting on the medial side of the ischium followed by a second pass to cut the lateral side. A lane is used for protection (Reproduced with permission from the Division of Orthopaedic Surgery, Children's Hospital of Philadelphia)

Fig. 6 The position and depth of the cut can be periodically confirmed on the false profile view. The osteotome should be externally rotated such that the blade is on the "edge" on the fluoroscopic image (Reproduced with permission from the Division of Orthopaedic Surgery, Children's Hospital of Philadelphia)

Fig. 7 Retractors are needed for protection but obscure visualization. The position of the osteotome can be confirmed by periodically withdrawing the lane (Reproduced with permission from the Division of Orthopaedic Surgery, Children's Hospital of Philadelphia)

the surgical plane. Sharp extraperiosteal dissection with a scalpel can release any remaining muscle fibers. The psoas can then be retracted to reveal the pubic eminence, an important landmark that constitutes the next "bump" medial to the AIIS. In order to avoid injury to the triradiate cartilage and the acetabulum, the pubis cut must stay medial to this structure (Fig. 11). The iliopectineal fascia is first opened cephalad to the pubic ramus using a right-angle clamp. A lane retractor can then be passed around the superior edge of the ramus in an extraperiosteal fashion. The inferior edge of the ramus is slightly more difficult to define, but similar use of a Crego elevator followed by a lane can help create this channel. A Statinski vessel clamp can then be passed extraperiosteally from distal to proximal through the obturator foramen; a long Schnitt can be used to transfer a suture loop to the Statinski which can in turn be used to shuttle a Gigli saw around the pubic ramus (Fig. 12). Before the saw is passed, the shuttle suture is pulled taut to be sure that the adductor musculature does not contract which would indicate entrapment of the obturator nerve. While the pubis can be cut with other

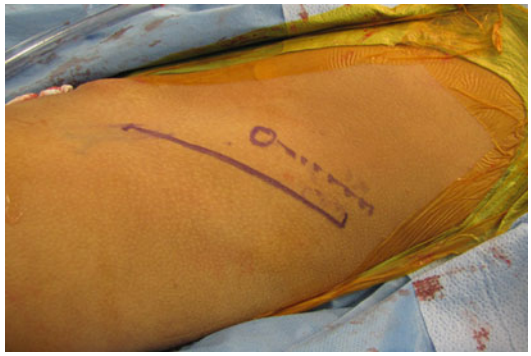

Fig. 8 Skin incision for the anterior exposure (Reproduced with permission from the Division of Orthopaedic Surgery, Children's Hospital of Philadelphia)

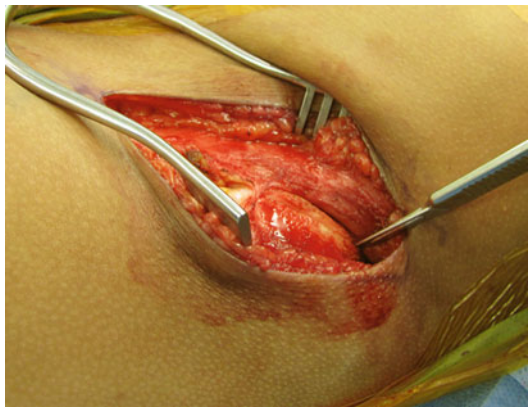

Fig. 9 Splitting of the apophysis (Reproduced with permission from the Division of Orthopaedic Surgery, Children's Hospital of Philadelphia)

techniques (e.g., osteotome), use of a Gigli saw ensures a complete cut including the overlying and often thick periosteum.

Iliac Cut

The iliac cut generally starts just distal to the ASIS and is shaped somewhat similar to Kalamchi's modification of the straight Salter osteotomy [7]. A 3.2 mm drill hole is made approximately 1 cm above the pelvic brim in line with superior aspect of the sciatic notch on the false profile view (Fig. 13). An oscillating saw is used to perform

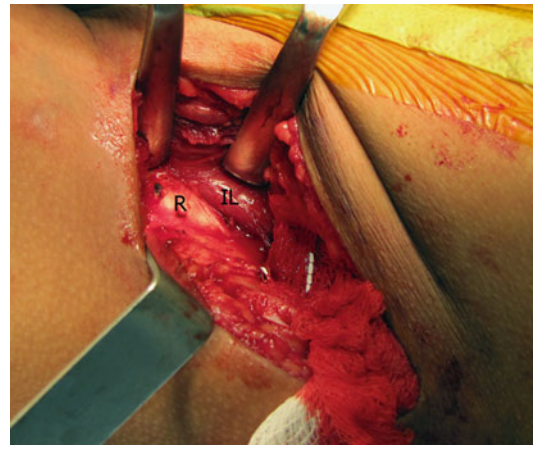

Fig. 10 The interval between the rectus tendon (*R*) and the iliacus (*IL*) is identified (Reproduced with permission from the Division of Orthopaedic Surgery, Children's Hospital of Philadelphia)

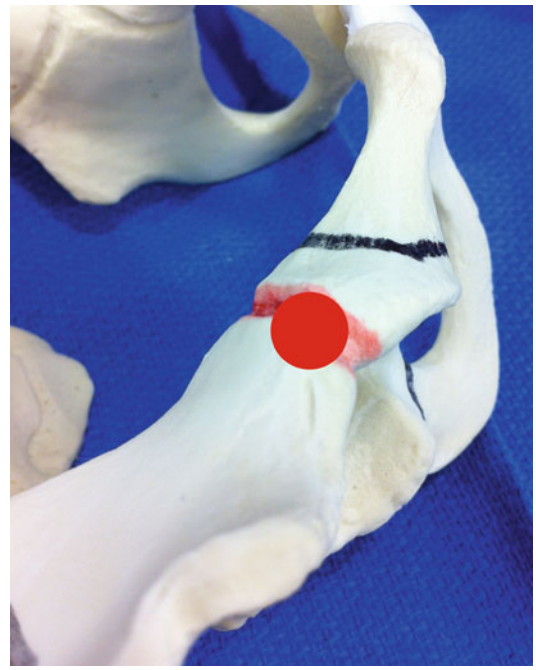

Fig. 11 The pubis cut (*black line*) must be made medial to the pubic limb of the triradiate cartilage (*red line*). The pubic eminence (*red dot*) can be palpated easily and is an important landmark for this cut (Reproduced with permission from the Division of Orthopaedic Surgery, Children's Hospital of Philadelphia)

Fig. 12 A Statinski clamp is used to shuttle a suture (and then a Gigli saw) around the pubic ramus (Reproduced with permission from the Division of Orthopaedic Surgery, Children's Hospital of Philadelphia)

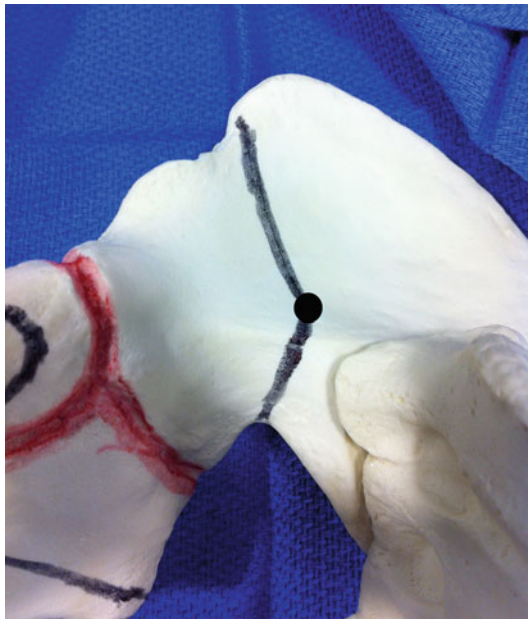

Fig. 13 Orientation of iliac osteotomy. A drill hole (*black dot*) is placed 1 cm above the pelvic brim. This allows the surgeon to control the directional change in the osteotomy (Reproduced with permission from the Division of Orthopaedic Surgery, Children's Hospital of Philadelphia)

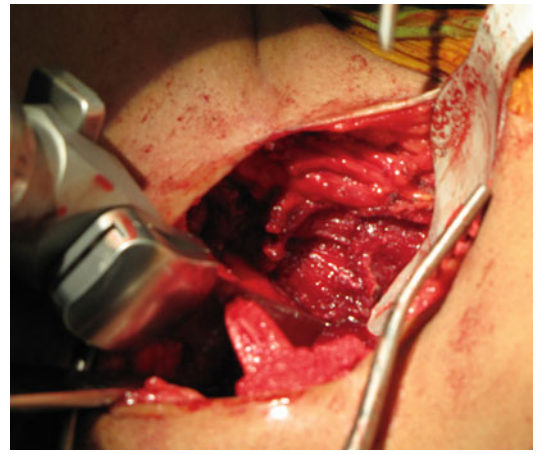

Fig. 14 The first segment of the iliac osteotomy is performed with an oscillating saw (Reproduced with permission from the Division of Orthopaedic Surgery, Children's Hospital of Philadelphia)

the first segment of the osteotomy connecting the starting point and the drill hole (Fig. 14). With a reverse Homan in place to protect the contents of the sciatic notch, the corner of a straight Ganz or flat chisel is placed in the drill hole and aimed directly into the notch (Fig. 15). Use of a laminar spreader can facilitate completion of the osteotomy. Performing this angled cut allows bony contact close to the point in the pelvis where the mechanical forces are transmitted, thereby improving stability and fixation and obviating the need for a large structural bone graft.

Mobilization of the Fragment and Fixation

Assuming all of the cuts are complete, a 4 mm Schanz screw is placed into the acetabular fragment just distal and parallel to the first segment of the iliac cut. A Weber tenaculum is then placed around the superior pubic ramus exiting proximal to the Schanz screw. Grasping the screw with a T-handle chuck in one hand and the Weber with the opposite hand allows complete control over the acetabular fragment. Similar to a periacetabular osteotomy, positioning

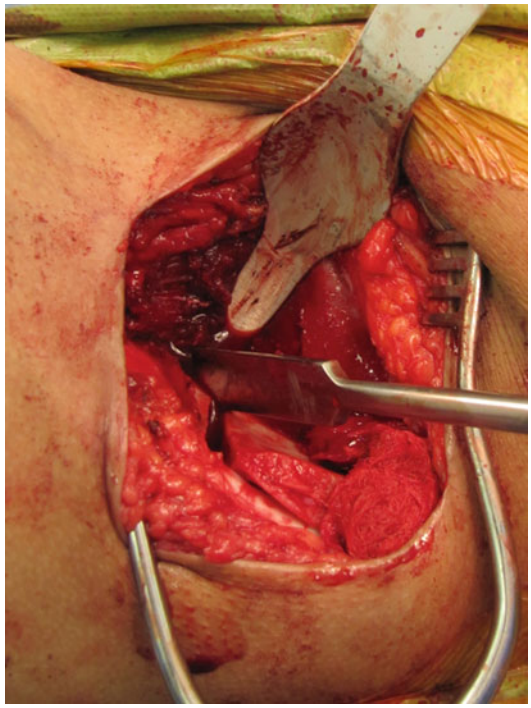

Fig. 15 With a reverse Homan in place to protect the contents of the sciatic notch, the corner of a straight Ganz or flat chisel is placed in the drill hole and aimed directly into the notch (Reproduced with permission from the Division of Orthopaedic Surgery, Children's Hospital of Philadelphia)

Fig. 16 The acetabular fragment is positioned with the help of a Schanz screw and held provisionally with K wires (Reproduced with permission from the Division of Orthopaedic Surgery, Children's Hospital of Philadelphia)

of the acetabular fragment is critical and should be tailored to the particular pattern of deficiency. In general, anterior coverage is provided by angling the Schanz screw distal, anteversion by angling the screw medial, and lateral coverage by rotating the fragment externally about the axis of the screw itself. Three to four 3/32 Kirschner (K) wires are inserted through the proximal ilium and into the acetabular fragment to get provisional fixation (Fig. 16). AP and false profile views of the operative hip and the entire pelvis using the image intensifier are necessary to confirm proper coverage, version, and sourcil position. In addition one should confirm that the wires are positioned away from the joint and the triradiate cartilage. The length of the K wires are then measured by placing an additional K wire next to the exiting portion and measuring the difference with a ruler. Each K wire can then be sequentially exchanged for a long 3.5 mm pelvic screw for definitive fixation (Fig. 17).

Closure

If a sharp spike is present on the acetabular fragment, this can be trimmed at the level of the AIIS and used to bone graft the iliac osteotomy. A drain is placed along the inner table and brought out through the Smith-Peterson interval. The apophysis of the iliac crest is repaired with a deep-deep, superficial-superficial double throw using absorbable 0 or 1-0 suture which improves apposition of the cartilage surfaces (Fig. 18). The external oblique is repaired with a running 2-0 suture followed by additional running layers in the dermis and the subcutaneous layer.

Postoperative Management

Depending on the patient's ability to comply with postoperative weight-bearing restrictions, a single-leg spica cast can be used for postoperative immobilization. Otherwise, the patient may be

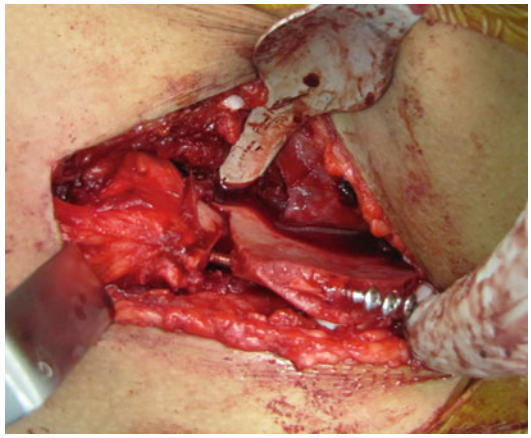

Fig. 17 Definitive fixation of the osteotomy with 3.5 mm pelvic screws (Reproduced with permission from the Division of Orthopaedic Surgery, Children's Hospital of Philadelphia)

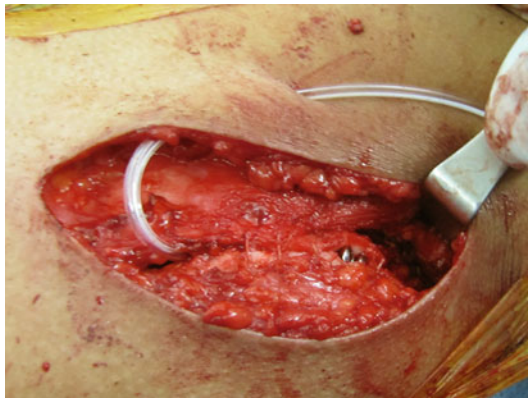

Fig. 18 Closure and drain placement (Reproduced with permission from the Division of Orthopaedic Surgery, Children's Hospital of Philadelphia)

kept touchdown weight bearing. At 4–6 weeks depending on the degree of bony healing, weight bearing is generally progressed and physical therapy started for gait training and abductor strengthening.

Pearls and Pitfalls

- Angling the ischial cut above the ischial spine removes the tethering effects of the sacrospinous ligament and aids in the mobilization of the acetabular fragment.

Fig. 19 Preoperative anteroposterior (*AP*) radiograph of the pelvis (Reproduced with permission from the Division of Orthopaedic Surgery, Children's Hospital of Philadelphia)

- Using a Gigli saw passed extraperiosteally around the pubic ramus ensures that the pubis (which can be thin and flexible in this age group) is completely cut and freed from its thick periosteal connections.
- Performing the Kalamchi modification of the Salter iliac cut allows bony contact close to the point in the pelvis where the mechanical forces are transmitted, thereby improving stability and fixation and obviating the need for a large structural bone graft.
- Unlike the PAO, intraoperative imaging to assess acetabular position after correction can be quite difficult in the triple osteotomy because the bony acetabular rim is not well defined in these younger patients. As a result, one must be quite careful to avoid overcoverage. It is sometimes helpful to place a clamp at the edge of the palpated acetabular rim and use the image intensifier to help estimate coverage.

Case Example

An 11-year-old female presented with a pain and a limp. An AP pelvic radiograph demonstrates subluxation and acetabular dysplasia of the left hip (Fig. 19). She underwent a modified Bernese triple osteotomy. AP pelvic radiograph taken

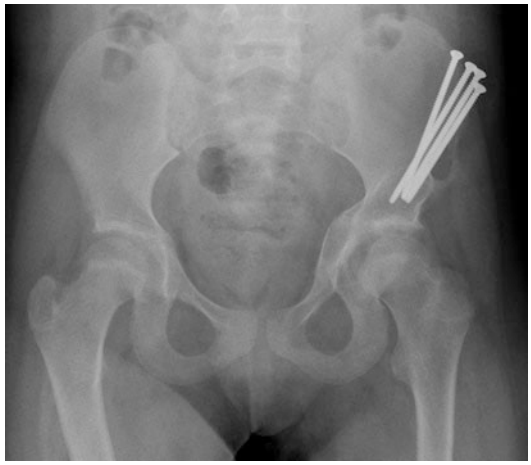

Fig. 20 AP pelvic radiograph 2 years following surgery (Reproduced with permission from the Division of Orthopaedic Surgery, Children's Hospital of Philadelphia)

two years after surgery demonstrates a healed osteotomy. The left hip is now reduced with improved femoral head coverage and a horizontal sourcil (Fig. 20).

Summary

The triple innominate osteotomy is a complete redirectional acetabular osteotomy, consisting of cuts through the ilium, ischium, and pubis. Unlike a periacetabular osteotomy (Ganz), the triple does not violate the triradiate cartilage and can therefore be performed in the skeletally immature. In contrast to most other pelvic osteotomies, this procedure completely frees the acetabulum from the rest of the pelvis which in turn allows the surgeon to obtain large corrections and control the final position of the acetabulum in multiple planes. The modified Bernese triple osteotomy is performed through two incisions. The medial approach allows access for the ischial osteotomy, while the anterior exposure is used for the osteotomies of the pubis and ilium. Definitive fixation is obtained with long pelvic screws.

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