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Pelvic Ring Disruption—Malalignment

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Optimal initial care can reduce the occurrence of pelvic ring malreductions; however, nonunions and malunions may still occur.[1-4] Tile[5] estimated a 5% incidence of residual severe deformity in major disruptions of the pelvic ring. However, nonoperative management of vertically unstable pelvic ring injuries can lead to malunion and/or nonunion in 55% to 75% of cases.[4,6] The factors that lead to malreduction of pelvic ring disruptions include injury factors, surgeon factors, and patient factors. Pelvic malunions often present with pain posteriorly,[7] but can also present with neurologic, gynecologic, or urologic problems. Additional presentations include imbalance during sitting, lying, or standing (Table 16-1).

Prevention: Surgical Techniques and Reduction

The key for the orthopedic surgeon to prevent pelvic malunions is to understand the deformity, anatomically reduce the pelvis, and then adequately stabilize to pelvis to prevent loss of reduction. The most common deformities include cephalad and posterior translation and internal rotation of the hemipelvis.[3,8-11] Despite the limited bony stability of the pelvis, once operative reduction and fixation occurs, having the pelvis anatomically reduced significantly increases the stability of the construct[12] (Figure 16-1). Furthermore, malreduced fractures may make safe iliosacral screw fixation impossible. In classifying pelvic injuries, the most significant information to the orthopedic surgeon is: 1) where the pelvis is broken, 2) the stability of the fracture, and 3) the actual deformity that is occurring in the pelvis. The specific location of the injury is easily defined during the radiographic evaluation (anteroposterior, inlet, outlet, and computed tomography scan of the pelvis).

Archdeacon M, Anglen J, Ostrum R, Herscovici D.
Prevention and Management of Common Fracture Complications (pp 157-164).

Table 16-1
Risk Factors for Pelvic Malunion

Factor	*Implication/Result*
Injury factors	Posterior disruption of the pelvis.
Surgeon factors	Failure to understand the deformity of the pelvic disruption. Failure to obtain anatomical reduction at surgery.
Patient factors	Healing of the pelvic malreduction prior to operative intervention (patient instability, soft tissue injuries, infections, etc). Failure of fixation after anatomical reduction of pelvic disruption (patient noncompliance, etc).

Figure 16-1. An inlet view of the pelvis with the spine removed showing the inherent instability of the bony architect if the sacroiliac ligaments were disrupted.

Defining the stability of the pelvis is more complex. Stability is defined as the ability of the pelvic ring to withstand physiologic forces without abnormal deformation. The stability of the pelvis is determined both by physical exam and radiographic evaluation. An anterior/superior iliac spine (ASIS) compression test and iliac wing compression test should be performed. Radiographic signs of instability include sacroiliac displacement of greater than 5 mm in any plane. Also, a posterior fracture (ilium or sacral) fracture gap may signify instability. Using the combination of radiographs and physical exam, the surgeon can determine whether the pelvis is stable.

The most critical analysis of the injury prior to fixation is the actual deformity of the pelvic ring. Only by defining the deformity can the surgeon plan the appropriate reduction maneuvers. Unfortunately, the complexity of the pelvis makes analysis of the deformity quite difficult. It is helpful to think of the deformity on an X, Y, and Z axis[1,3,9] (Figure 16-2). Each axis has a translational deformity as well as a rotational deformity, including X axis diastasis or impaction with flexion-extension, Y axis cephalad-caudad translation with internal-external rotation, and Z axis anterior-posterior

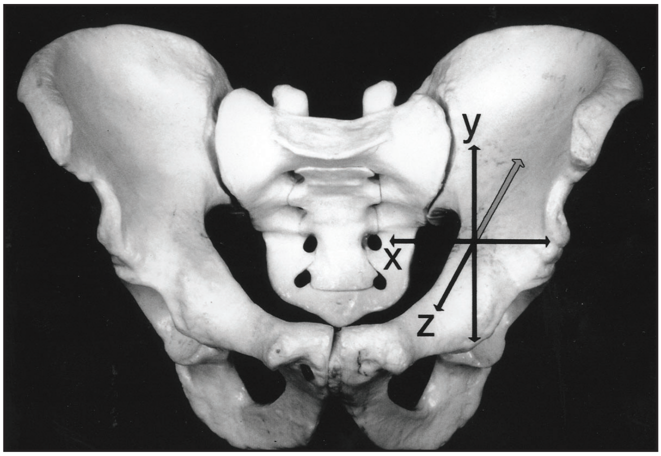

Figure 16-2. A pelvis with the three axes superimposed. Each axis has a translational deformity and a rotational deformity:

X-axis	Translation	Impaction/Diastasis
	Rotation	Flexion/Extension
Y-axis	Translation	Cephalad/Caudad
	Rotation	Internal/External Rotation
Z-axis	Translation	Anterior/Posterior
	Rotation	Abduction/Adduction

translation with abduction-adduction. Radiographic landmarks are essential in planning and assessing reduction. Cephalad translation can be assessed with a transverse line parallel to the cephalad border of the sacrum followed by perpendicular lines measuring the dome height (leg length discrepancy) and ischial height (sitting imbalance), while rotational deformities are only accurately assessed with a true anteroposterior (AP) of the sacrum (Figure 16-3).

Reduction of the SI joint or the posterior pelvic injury is critical prior to fixation. Closed reduction and percutaneous fixation can often be achieved within the first 48 hours of injury using table traction, external fixators, the femoral distractor, and/or half pins as joy sticks.[13] Definitive fixation of posterior pelvic injury often uses iliosacral lag screws. Anterior sacral iliac plating and transiliac bars or plating are also options. If closed reduction fails to obtain an anatomical reduction and/or if more than 48 hours have passed since the injury occurred, open reduction internal fixation (ORIF) of the posterior pelvic injury may be indicated.

Prevention: Implant Selection and Application

In general, in completely unstable pelvic injuries, the posterior hemipelvis requires reduction prior to the anterior pelvis as even a few millimeters of rotation anteriorly can translate into significant malalignment posteriorly. Reduction of the symphysis is often accomplished using a Weber clamp through an anterior pelvic

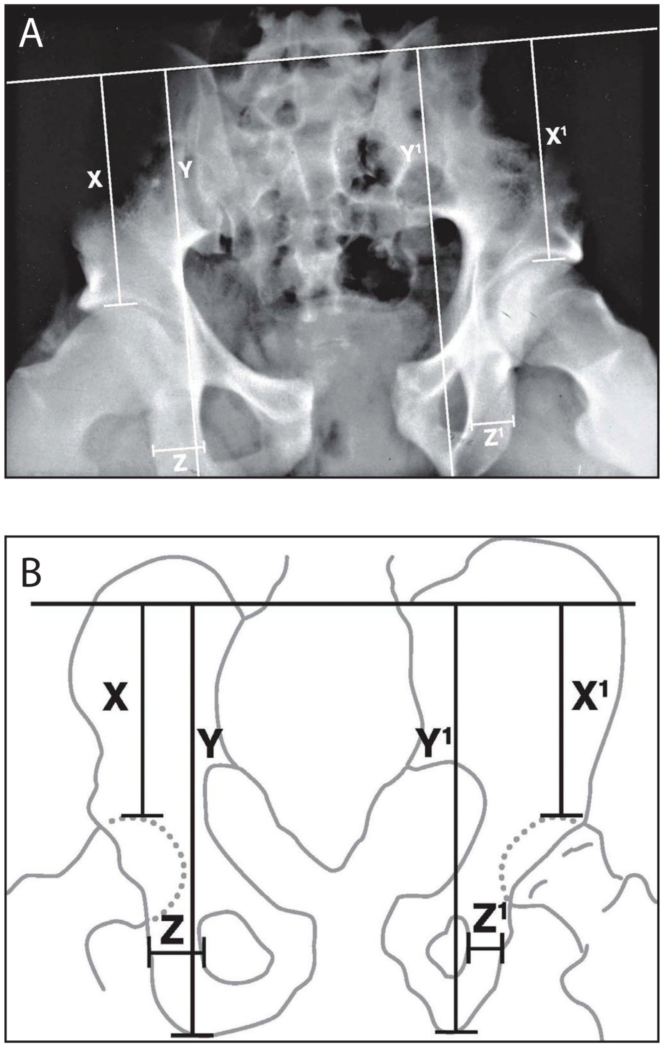

Figure 16-3 (A,B). Demonstration of the method of linear measurement of deformity using the AP radiograph of the pelvis obtained before the application of an external fixator in a 26-year-old pedestrian struck by a motor vehicle and a corresponding line drawing. First, a line (unlabeled horizontal line in these figures) is drawn parallel to the x axis (as defined in Figure 16-2). Often, the remaining bilaterally intact sacral foramina can be used as guides to draw this line. Next, lines are drawn perpendicular to this first line, ending at the acetabular roof of the uninjured (X) and injured (X1) hemipelves, as well as the distal aspect of the ischium (Y and Y1, uninjured and injured sides, respectively). Comparing X to X1 provides a measure of leg length, and comparing Y to Y1 provides a measure of sitting (ischial) imbalance. The width of the ischium (Z and Z1, uninjured and injured sides, respectively) increases as internal rotation of the hemipelvis increases.

approach. Alternatively, a Jungbluth clamp can reduce the symphysis and assist with the SI reduction as well.

With the patient prone, open reduction of the posterior ring injury (SI joint) is facilitated with an angled Matta clamp placed through the sciatic notch with one prong on the sacral ala or midline sacrum and the other on the outer iliac wing (Figure 16-4).[14] This helps reduce external rotation deformities as well as diastasis of the posterior pelvic injury. Additionally, a Weber clamp is placed from the posterior superior iliac spine (PSIS) to the sacral spinous process and reduces cephalad displacement and internal rotation deformities of the hemipelvis. The key to reduction is with a combination of clamps that create the reduction vector for anatomical reduction. Often, subtle manipulation of clamp placement will correct the deformity. Once anatomical reduction is achieved on the inlet, outlet, AP, and lateral views, iliosacral screws are the main form of posterior fixation. Posterior tension band plating can be performed as well using a 14- to 16-hole recon plate placed at the superior portion of the sciatic notch below the PSIS. These tension band plates are used in cases of sig-

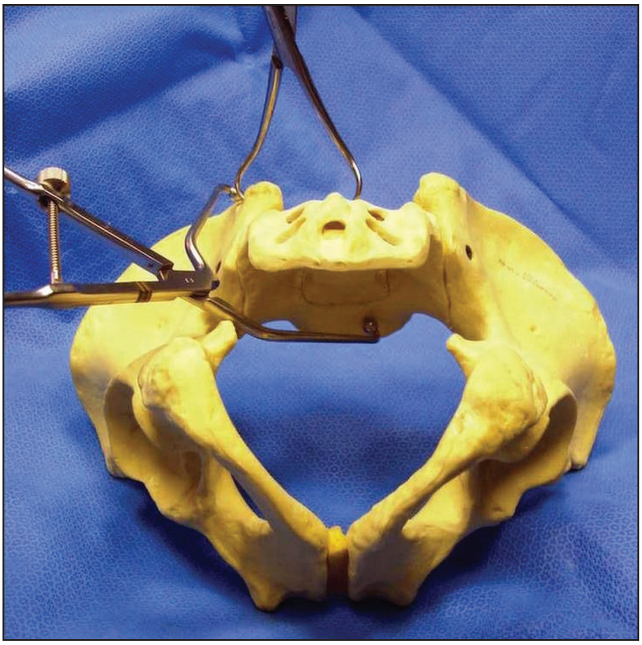

Figure 16-4. Reduction clamp placement on SI joint displacement.

nificant comminution of the sacrum and/or severe osteoporosis and are often used as an adjunct to iliosacral screws.

Posterior crescent fractures can be approached from the anterior approach; however, in most of these cases, the fracture will be difficult to visualize (ie, the sacral fracture is more medial or the crescent fracture is posterior to the SI joint). The author prefers in these cases a posterior approach if the soft tissue will allow it. This allows a direct visualization of the fracture site, which is either posterior to the SI joint or enters the SI joint. If the posterior ilium fragment remains attached to the sacrum through the SI joint ligaments, SI joint fixation is not required. The deformity that is problematic is the internal/external rotation of the hemipelvis, which is somewhat difficult to manipulate from the back. A combination of reduction clamps and half pin joysticks are used to reduce the rotational deformity of the hemipelvis. A commonly used reduction method is to use small screw holding clamps (Farabeuf or Jungbluth) placed just cephalad to the top border of the sciatic notch to allow fixation above and below the clamp. The superior portion of the sciatic notch is excellent bone and allows good fixation of these crescent fractures. If difficulty is encountered in reducing the fracture, an angled Matta reduction clamp is placed through the notch with one point on the sacral ala and the other point on broken iliac wing. The clamp can internally or externally rotate the hemipelvis depending on its position. Careful clamp placement is important so that key areas for fixation, such as the sciatic buttress, are accessible. After anatomical reduction is achieved, lag screw fixation placed from the PSIS towards the ASIS secures the reduction followed by definitive plate fixation. Once the crescent fracture is reduced, the SI joint is evaluated for stability. If unstable, supplemental fixation with iliosacral screws is performed.

The rehabilitation of patients with completely unstable pelvic injuries involves touchdown weightbearing for a total of 8 weeks. Once 8 weeks have passed, weightbearing as tolerated with range-of-motion and resistive exercises are started. The patients with bilateral injuries are unfortunately wheelchair transfers for a total of 8 weeks. Most patients mobilize on the intact side and use crutches or walkers.

Complication Management: Salvage Procedures

As mentioned earlier, the best treatment is prevention.[2,4,7,15] The problem of malunions and nonunions appears most common after inadequate initial treatment of displaced fractures and unstable pelvic ring injuries.[6] From the technical standpoint, late correction is very difficult because the anatomy is altered; thus, the potential for complications is increased. Osteotomies can easily damage adjacent structures, and scarring around nerves prevents fragments from moving freely without causing nerve palsy.

Indications for surgery include pain, pelvic ring instability, and clinical problems relating to the pelvic deformity (gait abnormalities, sitting problems, limb shortening, genitourinary symptoms, vaginal wall impingement, etc). A thorough knowledge of pelvic anatomy is required to understand the three-dimensional deformity. Furthermore, extensive preoperative planning is needed to determine the proper order of exposures for release, reduction, and fixation. Because each patient is different, it behooves the surgeon to individualize the treatment.

Simple nonunions often do not require extensive anterior and posterior ring releases and reduction, and they respond to in situ fusion.[16] In nonunion cases with significant displacement, in situ fusions are unrewarding and leave the patient with complaints related to deformity as well as pain (Figures 16-5, 16-6, and 16-7). For malunions of the pelvis, the surgical technique often involves a three-stage procedure as described by Letournel.[2,3,8] The three stages are performed with the patient supine-prone-supine or prone-supine-prone. After each stage, the wound is closed, and the patient is turned to the opposite position. The first stage mobilizes anterior or posterior injuries by an osteotomy of the malunion or release of the nonunion. The second stage involves release and mobilization of the opposite side. The most important part of the second stage is the reduction of the pelvic ring. However, this stage also includes an osteotomy, mobilization, or both of that side of the ring. Following reduction, the second stage is completed by fixation of that particular side of the pelvic ring. The third stage completes the reduction and fixation of the opposite side (relative to the second stage) of the pelvic ring. The key to reduction is to recognize the deformity, adequately release the deformity, and create a force vector to reduce the deformity. Because these reconstructions are very complex with a high risk of complication, they should be referred to surgeons with experience in their management.

Summary

The one-, two-, or three-stage pelvic reconstruction for pelvic malunion or displaced nonunion has benefitted most patients. However, the results of surgery in this setting are not as predictable as the results of acute treatment of pelvic ring injuries, and the rate of complications is higher.[3,8] Once the deformity has been established and chronic symptoms develop, the probability of surgical reconstruction returning the patient to his or her preinjury status is decreased. Prevention by acute anatomic closed or open reduction and internal fixation of unstable pelvic injuries is the best treatment for pelvic malunions and nonunions.

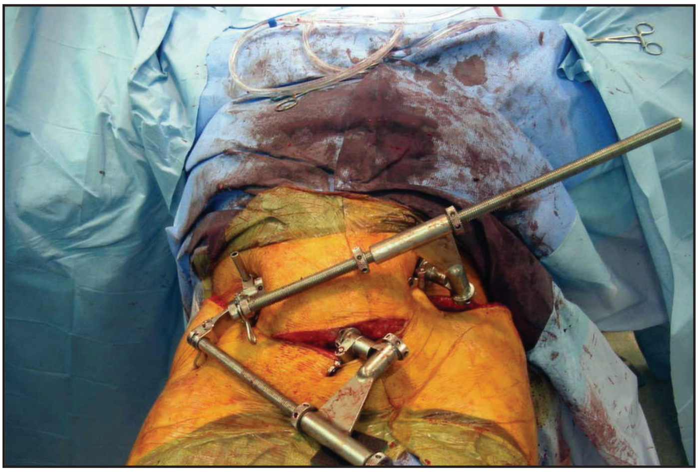

Figure 16-5. Patient presented 1-year postinjury with pain, deformity, and feeling as if he or she was "walking crooked." AP, in x-ray of pelvis from the time of injury demonstrating the rotational deformity.

Figure 16-6. Intraoperative photos illustrate the application of femoral distractors to create the necessary force vectors for correction of the deformity. This was the second part of a two-stage procedure. The first stage involved removal of the SI screws. In the second stage, bilateral sacral osteotomies were performed in conjunction with anterior and posterior pelvic fixation. A wedge of bone was removed from the osteotomy site on one side and was used to graft the opposite side.

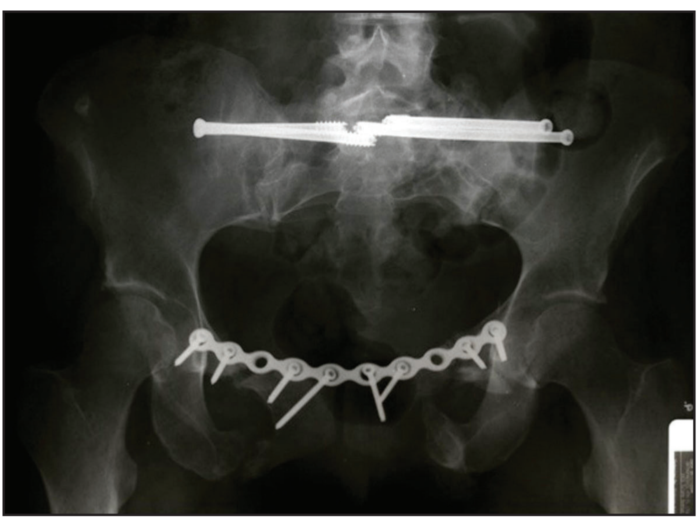

Figure 16-7. AP, inlet, and outlet x-rays of pelvis 18 months postoperative.

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