Review Article

# Pelvic Fractures: Part 2. Contemporary Indications and Techniques for Definitive Surgical Management

Joshua R. Langford, MD
Andrew R. Burgess, MD
Frank A. Liporace, MD
George J. Haidukewych, MD

## Abstract

Once the patient with pelvic fracture is resuscitated and stabilized, definitive surgical management and anatomic restoration of the pelvic ring become the goal. Understanding injury pattern by stress examination with the patient under anesthesia helps elucidate the instability. Early fixation of the unstable pelvis is important for mobilization, pain control, and prevention of chronic instability or deformity. Current pelvic fracture management employs a substantial amount of percutaneous reduction and fixation, with less emphasis placed on pelvic reconstruction proceeding from posterior to anterior, and most reduction and fixation of unstable pelvic fractures done with the patient supine. Compared with control subjects with acetabular fracture or pelvic fracture alone, patients with combined injury have a significantly higher Injury Severity Score, lower systolic blood pressure, and higher mortality rates; they are also transfused more packed red blood cells. Even with anatomic restoration of the pelvis, long-term outcomes after severe pelvic trauma are below population norms. The most common chronic problems relate to sexual dysfunction and pain. Regardless of fracture type, neurologic injury is a universal harbinger of poor outcome.

From the Orlando Regional Medical Center, Orlando, FL.

*J Am Acad Orthop Surg* 2013;21: 458-468

http://dx.doi.org/10.5435/JAAOS-21-08-458



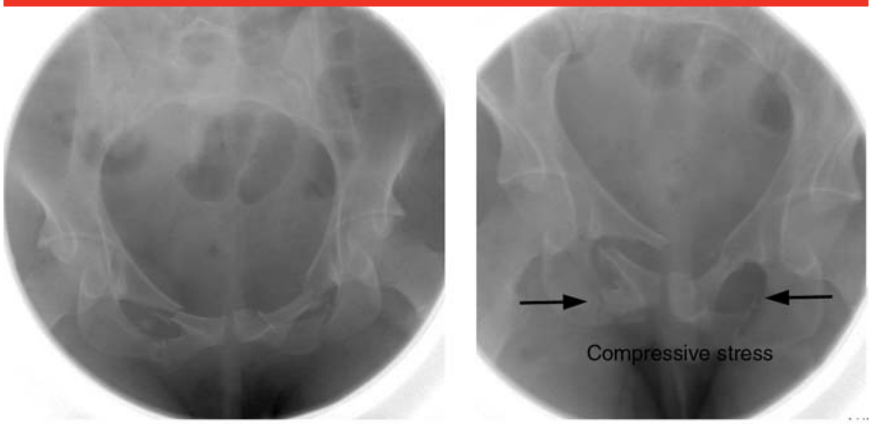
Surgical decision making with pelvic injuries is a complex process. After temporizing measures (eg, pelvic binders) have been addressed and the patient resuscitated, definitive fixation is undertaken. Specific surgical indications for pelvic injuries are as varied as the injuries themselves.

## Indications

### Anteroposterior Compression Injuries

Nonsurgical management is preferred for anteroposterior compression (APC) type I injuries (see part 1 of this series), in which the symphysis is widened <2.5 cm and there is no widening of the sacroiliac (SI) joint; however, confirmation is sometimes needed to rule out an occult APC type II injury.[1,2] If there is any doubt of the stability of the injury, an examination under anesthesia will help delineate the entirety of the injury.[2,3] For patients presenting to the outpatient clinic with a notable amount of pain after an APC type I injury, a single-leg stance view can provide the dynamic stress needed to rule out rotational instability.[4]

Figure 1




A B

**A,** Pre-stress AP pelvic radiograph. **B,** AP radiograph with internal rotation stress being applied to the pelvis (arrows), demonstrating complete collapse of the right hemipelvis (superior ramus almost across the midline).

For APC type II injuries, surgical stabilization is generally indicated.[5] The literature on indications for this injury is scant at best, largely consisting of studies without control groups. No study (prospective or retrospective) in the literature compares APC type II injuries managed surgically versus nonsurgically. Despite the lack of papers on indications, the long-term outcomes following fixation of these unstable injuries often leads to excellent results.[6,7] In contrast, the sequelae of a missed unstable pelvic injury can be devastating to the patient. The surgical options for management of chronic instability and pain related to a missed injury are complex and associated with more unpredictable outcomes when treated in a delayed setting.[8]

Determining the need for posterior fixation is a point of debate. To assist in decision making, a recent study introduces a modification to the Young-Burgess classification and attempts to subclassify APC injuries based on the amount of sagittal plane rotation.[3] In an APC type IIa injury, the posterior SI ligaments are intact and anterior fixation alone will likely be sufficient for management. In an APC type IIb injury, the posterior SI ligaments are attenuated, which may contribute to more sagittal plane rotational instability of the hemipelvis. On dynamic stress views, this sagittal plane instability manifests with vertical changes at the pubis and should be considered unstable if there is >1 cm of displacement.[3] If this instability is present, supplementing the anterior fixation with posterior ring stabilization via an iliosacral screw is preferable.

For APC type III injuries, anterior and posterior fixation is required because of the complete instability of the hemipelvis. Often, these patients are managed with temporizing measures (ie, antishock sheet/binder, external fixation) during resuscitation and then later are converted to definitive fixation with an anterior plate and iliosacral fixation. This conversion is usually performed during the first week.

## Lateral Compression Injuries

The lateral compression (LC) injury is also graded from I to III. One of the most common pelvic injuries is the LC type I, which is an injury to the superior and inferior pubic rami as well as impaction to the sacrum. The great majority of patients are treated nonsurgically with weight bearing to tolerance on the affected side and have a low risk of displacement.[9] Considerable controversy surrounds the optimal management of this injury mostly because of the extreme variability in fracture stability.

For a given static displacement on an AP radiograph, great variability on dynamic stress views can be noted. For an LC type I injury, no consensus exists regarding how much dynamic instability can be tolerated. In general, if a patient has too much pain to move out of bed, then performing an examination under anesthesia may be warranted (Figure 1).

In addition to compression testing,

Dr. Langford or an immediate family member serves as a paid consultant to Stryker and has stock or stock options held in the Institute for Better Bone Health, LLC. Dr. Burgess or an immediate family member is a member of a speakers' bureau or has made paid presentations on behalf of, and has stock or stock options held in, Stryker. Dr. Liporace or an immediate family member has received royalties from Biomet; is a member of a speakers' bureau or has made paid presentations on behalf of Biomet, Synthes, Stryker, and Medtronic; serves as a paid consultant to Biomet, Medtronic, Synthes, and Stryker; and serves as an unpaid consultant to AO. Dr. Haidukewych or an immediate family member has received royalties from DePuy and Biomet; serves as a paid consultant to Smith & Nephew, Synthes, and DePuy; has stock or stock options held in Orthopediatrics and the Institute for Better Bone Health; has received nonincome support (such as equipment or services), commercially derived honoraria, or other non–research-related funding (such as paid travel) from Synthes; and serves as a board member, owner, officer, or committee member of the American Academy of Orthopaedic Surgeons.

performing a push-pull test of the hemipelvis will help demonstrate sagittal plane instability. Much like an APC injury, the posterior LC injury may be more complex than a pure coronal plane internal rotation injury. Sagittal plane deformity (flexion/extension of the hemipelvis) may occur though an unstable sacral injury. Therefore, if there is evidence of sagittal plane instability (ie, >1 cm of displacement), then posterior fixation, in addition to anterior fixation, will help avoid further displacement.

Although rare, a unique LC injury that requires intervention is the so-called locked symphysis. During severe lateral compression, the symphysis can tear, and the intact pubic body may cross over the uninjured side and get locked into the obturator ring. Occasionally, grasping the iliac crests and using the figure-of-4 position of the legs reduces this dislocation by closed means. If reduction is possible and if the pelvis is stable, no further treatment is necessary. If closed reduction fails, then open treatment is required. Often, there is an associated bladder or urethral injury.[10,11]

Another LC variant is the "tilt" fracture, in which the superior ramus rotates through the symphysis and is pushed posteriorly and inferiorly into the perineum. In female patients, this injury may lead to dyspareunia (pain with intercourse). To help avoid later dyspareunia, surgical management is often undertaken to reduce the fracture.

## Vertical Shear Injuries

A vertical shear (VS) injury is one that involves a complete injury to the ligamentous structures on one side of the pelvis, typically resulting in cephalad displacement of the hemipelvis. The injury usually involves the ramus or pubic symphysis, in addition to either a complete SI dislocation or complete vertical sacral injury. Occasionally the injury may occur through the posterior ilium, leaving a crescent attached to the sacrum, which initially resembles the LC type II injury. Surgical fixation is indicated in all VS injuries.

## Combined Injuries

Although uncommon, unstable pelvic injuries may be associated with displaced acetabular fractures. Letournel et al[12] reported that unstable SI injury or symphysis disruption requiring fixation was present in 6.7% of patients with displaced acetabular fractures in their study. In a more recent series, 5.1% of patients had the so-called devastating dyad of combined unstable pelvic injury and displaced acetabular fractures.[13] Compared to control subjects with acetabular fracture or pelvic fracture alone, patients with a combined injury have a statistically significantly higher Injury Severity Score, lower systolic blood pressure, and higher mortality rates, and they are transfused more packed red blood cells.[13,14] Combined injuries are almost universally indicated for fixation because of their inherent instability.

# Fixation of the Anterior Ring

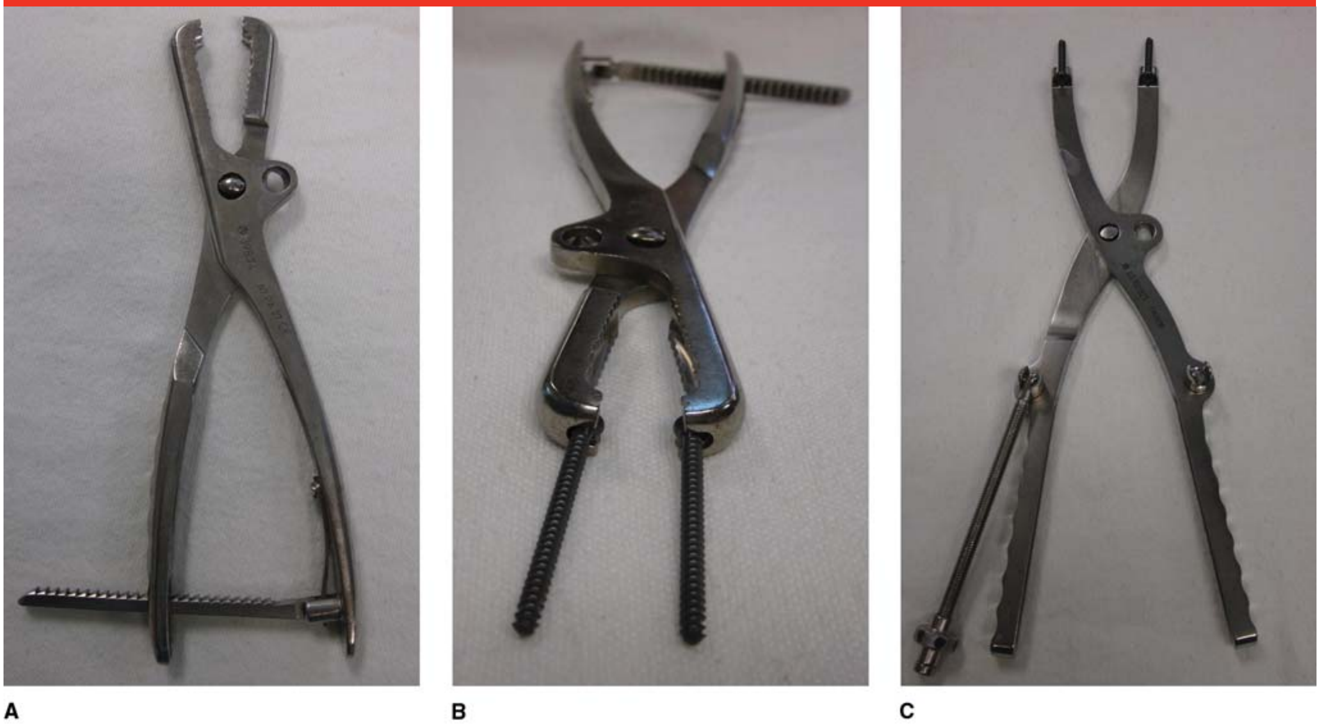
## Internal Fixation

The surgical approach for anterior fixation is through a Pfannenstiel-type incision. In the deep dissection, a vertical split in the linea alba will help preserve any remaining insertion of the rectus abdominus muscle that was not affected by the initial trauma. Exposure of the pubis to the pubic tubercle is usually adequate for symphysis disruptions. A pointed clamp with its points on each pubic tubercle is used for final manipulation of the reduction before plating. Alternatively, a Farabeuf or Jungbluth clamp (Figure 2) may be used to hold the reduction. For anterior ring patterns that involve ramus fractures as well as symphysis involvement, the surgeon can extend the exposure up the pelvic brim to gain fixation above the acetabulum through the midline incision. Familiarization with the anterior intrapelvic (modified Rives-Stoppa) approach is necessary to safely perform this fixation.[15]

Another method of anterior fixation is with percutaneous anterior plating.[16] Three incisions are created, one placed over each anterior superior iliac spine (exposing the iliac crest) and then a central Pfannenstiel-type incision, which is used to visualize the anterior pelvis. The pubis is not exposed in this approach because the plate is completely extrafascial. A plate is then tunneled across the front of the pelvis anterior to the neurovascular structures and is connected to each hemipelvis as well as in the midline to the pubic body. This type of fixation is useful for a multifocal anterior ring injury (ie, bilateral ramus fractures with symphyseal disruption).

In addition to plating techniques, fixation with a subcutaneous fixator was recently described and may be useful in both gaining a better mechanical advantage and minimizing pin tract infection associated with external fixation.[17] In this technique, pedicle screws (6 to 8 mm diameter) are placed from the anteroinferior iliac spine in the interosseous path toward the posteroinferior iliac spine. The method for inserting these pedicle screws follows most of the same steps as those for insertion of pins for a low anterior external fixator (see below). A bar is then passed subcutaneously across the front of the pelvis (above the fascia), and the screws are connected to maintain reduction (Figure 3). Special attention

Figure 2



A, Photograph of a Farabeuf clamp. Its jaws are good for grasping the pelvic wing, while the nose can grasp screw heads to perform reductions. **B,** Screws are temporarily inserted into the bone and left proud so that the Farabeuf can clamp onto the screw heads. A reduction can then be fine-tuned and compressed. **C,** Photograph of a Jungbluth clamp. Temporary screws are also used for this clamp. Unlike a Farabeuf, the Jungbluth can also be used to distract a fracture because the clamp circles the entire screw head.

must be directed to keeping the pedicle screw heads above the fascia and not pushing the rod down to meet the screw heads as this may cause compression and subsequent injury to the neurovascular bundles.

## External Fixation

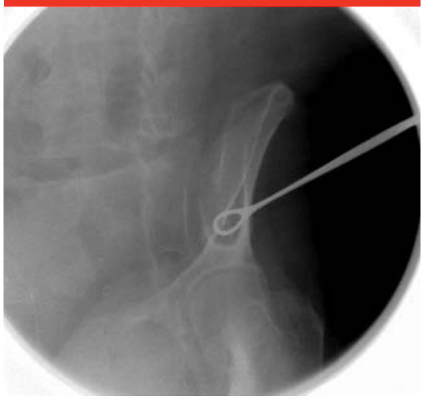
Alternatively, the anterior injury may be stabilized with external fixation. The pins start at the anterior inferior iliac spine and are directed toward the posterior ilium just superior to the greater sciatic notch. The use of hydroxyapatite pins provides improved long-term fixation for frames that are used for definitive care.[18,19]

The technique for insertion of anterior pelvic pins uses special radiographic views. To identify the corridor of bone in the pelvis, an obturator oblique outlet view is obtained (Figure 4). Using a metal instrument and fluoroscopy will help identify an adequate starting point in the supra-acetabular bone. The anatomic structures at greatest risk during this procedure are the hip capsule and the lateral femoral cutaneous nerve. The hip capsule reflection ends, on average, 16 mm above the joint but may be as high as 20 mm.[20] The mean distance from the pin insertion site to the lateral femoral cutaneous nerve is 10 mm but can be as close as 2 mm.[20] Once the trochar is on the pelvis, an iliac oblique inlet view will demonstrate that the pin is proximal to the hip joint and directed toward the sciatic buttress, proximal to the greater sciatic foramen (Figure 5). Next, the obturator oblique inlet view is obtained to demonstrate the interosseous path between the inner and outer tables of the pelvis (Figure 6). This view will help prevent early exit of the pin and can allow passage to the most posterior aspect of the ilium.

Figure 3

AP pelvic radiograph demonstrating an internal fixator for the management of multiple ramus fractures.

Figure 4



An obturator oblique outlet radiograph is used to identify the starting position to insert anterior pelvic pins.

Figure 5

Iliac oblique inlet radiograph demonstrating the starting point out of the hip capsule and the pin trajectory above the sciatic notch.

Figure 6

Obturator oblique inlet radiograph demonstrating the interosseous path to the posterior ileum.

## Fixation of the Posterior Ring

### Percutaneous Iliosacral Screws

Percutaneous iliosacral insertion that relies on radiographic landmarks has been described and is highly reproducible.[21,22] It is important to identify and line up the iliac cortical densities, which parallel the sacral ala and represent the anterior margin of the safe zone for iliosacral screw insertion. Respecting the anterior margin protects the L5 nerve root and the iliac vessels. The posterior safe zone on the lateral side is the identification of the upper sacral nerve root tunnel. The trajectory of the guidewire insertion depends on the desired compressive vector. For SI dislocations, a more posterior-to-anterior vector is desired, whereas for sacral fractures, a more transverse trajectory is desired.

The depth of wire insertion depends on the requirements of the screw. For comminuted sacral fractures, the wire may be inserted across the sacral body to the contralateral SI joint (transsacral screw). For standard SI dislocations, the wire is inserted to the midpoint of the sacral body or just beyond.

### Open Reduction of the Sacroiliac Joint

Reduction may be achieved from either a posterior or an anterior approach. For a posterior approach, the patient is placed in the prone position and the SI joint is exposed. Because the most posterior aspect of the ilium is dorsal and medial to the SI joint, direct visualization of the final reduction is not possible. After reduction, a percutaneous iliosacral screw is placed. Alternatively, posterior tension band plating or iliac bars may be employed for fixation. These devices are used in special circumstances (ie, severe sacral dysmorphism) in which safe iliosacral screw passage may not be possible.

An anterior approach using the lateral window of the ilioinguinal approach may be used. This allows a direct view of the cephalad joint. Fixation can be accomplished with SI plating, percutaneous iliosacral screws, or a combination of the two. The danger in this approach is the proximity of the L5 nerve root to the SI joint. This proximity of the L5 nerve root usually allows only one hole of a plate to cross onto the sacral ala. Therefore, if SI plating is to be used, two plates are necessary to gain control of the injured SI joint.[23] An alternative technique is to use anterior SI plates in addition to iliosacral screws, which has been shown to be one of the most stable constructs.[23]

## Techniques for Specific Injury Patterns

### Anteroposterior Compression Injuries

External fixation still has a place in the treatment of APC injury. Often, external fixation is a temporizing measure taken before conversion to definitive internal fixation. The half pins are not reduction devices in an APC injury. For a low anterior frame, the pins are inserted to the appropriate depth, and then two assistants push on the greater trochanters (providing a reduction force from posterolateral to the midline), followed by final tightening of the external fixator components. If iliac wing pins are chosen, two or three pins per side should be used in an attempt to ensure that at least one pin has adequate purchase between the inner and outer tables of the ilium. Our current indications for definitive external fixation with APC type injuries are for unstable pelvic injuries in the face of extraperitoneal bladder rupture as well as for management of the anterior injury in open pelvic fractures with contamination. This is often combined with percutaneous posterior iliosacral fixation.

When open treatment is undertaken, fixation is most often nonlocked plating of the pubic symphysis. Only one clinical study compares different internal fixation constructs for anterior pubis plating. Compared to a multi-hole construct, a two-hole plate has a higher rate of malunion and device failure.[24] Currently, the role of locked plating across the pubis is controversial and not thought to be beneficial.[25,26] Therefore, the choice of anterior fixation is often a multi-hole plate with at least two points of nonlocked fixation on either side of the symphysis. For an APC type IIb injury, the preferred management is to supplement this anterior fixation with posterior ring stabilization via an iliosacral screw.

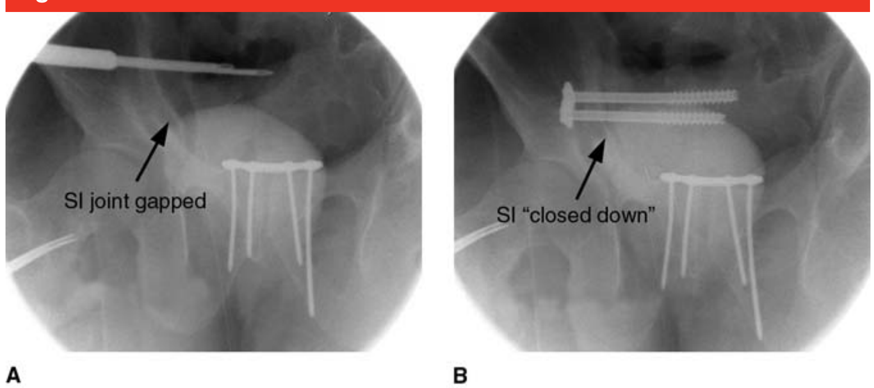
The classic teaching for an APC type III injury is to begin reconstruction and stabilization at the SI joint and progress anteriorly. With newer methods of percutaneous reduction, open reduction of the dislocation is not always needed. Multiple authors have reported favorable outcomes with a "front first" approach to management of these injuries.[7,27] A CT scan with the patient in the binder often reveals a closed anterior ring with a gapped, but aligned, SI joint. In this case, the binder may be left in place to assist in maintaining the reduction during anterior stabilization (Figure 7). In addition, internal-rotation taping of the feet will further assist reduction.[28] Maximizing these closed reduction maneuvers facilitates the procedure. It is then possible to perform anterior fixation with symphysis plating and then proceed to percutaneous iliosacral fixation using a partially threaded screw with a washer to "close down" the dislocation (Figure 8). If there is mild rotational deformity of the hemipelvis in the binder, then performing anterior fixation first may assist in achieving control of a posterior rotational injury (Figure 9). Alternatively, the anterior ring may be temporarily clamped, followed by percutaneous iliosacral screw placement, and then definitive anterior plating.

For SI dislocations that are completely displaced even in a binder, direct reduction must be performed. This is achieved by either an open reduction or a percutaneously guided reduction. For percutaneous reduction, one may use a frame attached to the bed and/or external fixation

**Figure 7**

Clinical photograph demonstrating the binder positioned farther down the thighs to maintain reduction in a patient with pelvic fracture.

**Figure 8**




**A,** Outlet radiograph of iliosacral guidewires in place with the sacroiliac (SI) joint still wide before placement of partially threaded screws. **B,** Outlet radiograph demonstrating that the iliosacral screws have "closed down" the gap.

**Figure 9**

AP radiograph of anteroposterior compression type IIb injury after binder placement, demonstrating sagittal plane rotational instability in addition to coronal instability.

**Figure 10**

A B

**A,** Three-dimensional CT reconstruction image of a lateral compression type II injury with iliac piece large enough for fixation. **B,** AP pelvic radiograph of fixation extending across to the uninjured hemipelvis to help anchor the fixation and resist displacement.

pins to provide enough force to complete and hold the reduction.[29] This method can achieve excellent reductions even in severely displaced dislocations.[30,31] When percutaneous methods of reduction are unsuccessful, open reduction is needed.

Our preference for open reduction is the anterior approach. The rationale for this preference also has to do with convenience and safety. By keeping the patient in a supine position, the entire injury may be managed with one draping while still giving anesthesia full access to the patient. When using the anterior approach, careful evaluation of the entire SI joint must be done to ensure that overcompression of the superior aspect of the joint has not occurred, thereby resulting in an abduction deformity of the hemipelvis.

## Lateral Compression Injuries

For an LC type I fracture, if the rami on the affected side cross the midline with compressive stress, then intervention with an anterior two-pin fixator held in distraction or an intramedullary superior ramus screw will reliably control the instability.[32] Recent reports have indicated that an oblique plane distraction may also be useful in resisting the instability associated with this injury.[33] This technique uses a traditional crest gluteus medius pillar pin (from iliac crest between the inner and outer table) on the unaffected hemipelvis and a low anterior pin on the affected side. For an LC type I injury with concomitant sagittal plane instability (ie, >1 cm of displacement on push/pull), an iliosacral screw is added to stabilize the posterior injury.

An LC type II injury is a posterior fracture either through the entire ilium or through the ilium and traversing a portion of the inferior SI joint (ie, crescent fracture) with associated ipsilateral rami fractures. In a crescent fracture, the fracture goes through the iliac wing and into the SI joint, yielding a rotationally unstable hemipelvis but with maintained stability to vertical forces.[34]

If open reduction is needed, the approach is dependent on the size and position of the iliac fragment. For an iliac wing injury that does not involve the SI joint, a posterior approach usually provides the best access for fixation. At times, even after fixation of the posterior pelvis, anchoring the construct to the opposite hemipelvis is needed to prevent postoperative displacement from continued instability (Figure 10). This pattern is often amenable to an "LC type II" screw, that is, one that uses the same corridor as low anterior half pins from the anterior inferior iliac spine back to the posterior ilium. This intramedullary fixation across the iliac fracture often yields a very stable construct.

Much like standard LC type II injuries, the method of fixation for crescent fractures is dependent on the remaining size of ilium attached to the sacrum. For fractures with large portions of ilium still attached, the lateral window of an ilioinguinal approach may be used. For intermediate-sized pieces, a prone approach with fixation along the iliac wing will permit stable fixation.[34] When the crescent leaves only a small piece of ilium, the injury may be managed with an iliosacral screw.[35,36] As with SI dislocations in an APC injury, a low anterior half pin may be used as a percutaneous reduction aid (Figure 11).

LC type III injuries generally result from severe crush-type mechanisms and are often referred to as a "windswept pelvis." Surgical treatment of LC type III injuries follows the same methods as those for LC and APC injuries, but in combination. Often, the externally rotated hemipelvis will need iliosacral fixation with a percutaneous screw. The anterior injury is varied, and management is according to the injury. Ramus fractures and pubis dislocations may both be managed with anterior plating or with external fixation. Often the compression side has a stable sacral injury that may need no surgical intervention. However, if there is an unstable posterior injury on the compression side, then our preference is to fix the posterior injury to build a stable platform for reconstruction of the contralateral externally rotated hemipelvis. Also, if one hemipelvis exhibits excessive internal rotation with a significant sacral crush, then it may need to be externally rotated and held with a fully threaded SI screw to allow for reduction and stabilization of the traumatically externally rotated hemipelvis.

## Locked Symphysis

To aid in reduction of this dislocation, a universal distractor may be employed with one pin in each hemipelvis. If this fails, an open approach for direct manual reduction is used.[10] If open reduction fails, an osteotomy of the superior ramus on the uninjured side will release the tension and allow for reduction.[11] If no bladder injury is present and instability persists after reduction, anterior plating is performed. For instability with concomitant bladder injury, a two-pin anterior fixator is used. Occasionally, the pelvis will be stable to stress after open reduction. In that situation, no further internal fixation is necessary.

## Vertical Shear

Surgical management of VS injuries can be very challenging because of the extreme forces that require neutralization. If the vertical component is a pure SI dislocation, then reduction and fixation of the posterior pelvic injury with iliosacral screws is performed. Every effort is made for an anatomic reduction because this is a predictor of better outcome for these injuries.[27] To assist in the neutralization of displacement forces, anterior fixation should be performed. More than one iliosacral screw for these severe injuries may be useful. This may be accomplished with either two screws in the S1 body, or one screw in the S1 body and one screw in the S2 body.

VS injuries with transforaminal sacral injury are difficult to manage with traditional iliosacral screw techniques.[37] Iliosacral screws depend on purchase on the dense cortical bone of the SI joint. In a vertical sacral fracture, purchase is limited to a short segment of cancellous bone from the fracture to the sacral body. To help mitigate this, some have advocated for transsacral fixation. These screws can be a combination of fully threaded and partially threaded screws, depending on their desired effect. While overcompression of a sacral nerve root is a theoretic possibility, no literature exists to support this concern. Another possibility for transsacral fixation is a locked construct in which the screw is threaded with a nut on the contralateral ilium. Early biomechanical and clinical experience has been encouraging at controlling vertical sacral fractures with this construct.[38,39]

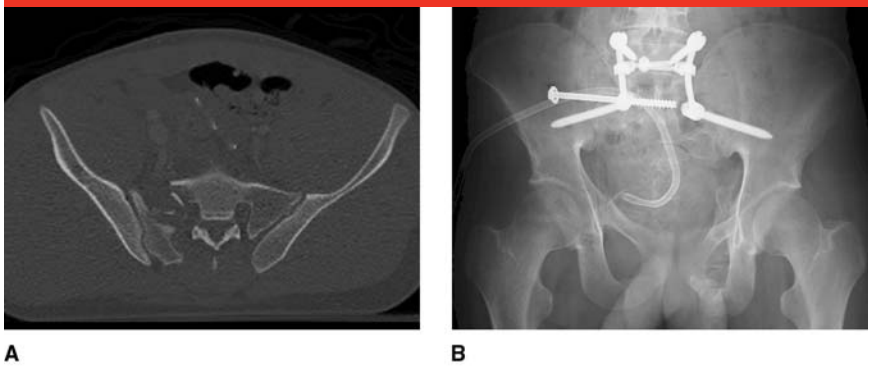
In addition to transsacral fixation, there have been many other attempts to solve the problem of vertical displacement in transforaminal sacral fractures, including iliac bars, transsacral plating, and spinopelvic fixation. "Connecting" the spine to the pelvis with instrumentation that engages both structures is referred to as spinopelvic fixation; the addition of an iliosacral screw to this construct is referred to as triangular osteosynthesis[40] (Figure 12). These constructs have demonstrated biomechanical superiority to traditional iliosacral screws.[41,42] In one study, triangular osteosynthesis was able to hold a reduction to healing in 95% of patients but was associated with a high complication rate, including wound problems, nerve injury, scoliosis, and delayed union.[43] Longer-term outcome studies of this technique are currently lacking and will be impor-

**Figure 11**

A B

**A,** Three-dimensional CT reconstruction demonstrating that a half pin may be used to reduce this lateral compression type III crescent fracture (arrow). **B,** Three-dimensional CT reconstruction of the same patient after percutaneous reduction, iliosacral screw placement, and anterior external fixation.

**Figure 12**



**A,** Axial CT scan demonstrating comminuted transforaminal sacral injury. **B,** AP pelvic radiograph after spinopelvic fixation (triangular osteosynthesis on the right).

tant to determining its place in the management of this fracture. In our practice, spinopelvic fixation is used for comminuted transforaminal sacral fractures from a VS mechanism that cannot be controlled with transsacral fixation.

## Combined Injuries

Surgical management of these injuries is complex, and consensus is limited on the order of reconstruction. In general, it is important to reconstruct a stable posterior base from which to build. With an anatomically reduced posterior ring, reconstruction of the acetabular columns may be easier. The most important aspect of the reconstruction is an anatomic reduction of the acetabulum. We generally prefer to anatomically reduce and stabilize the posterior pelvic injury, then proceed anteriorly to the acetabulum, and finally to the anterior pelvic ring injury.

## Postoperative Management

Postoperative protocols are as varied as the injuries themselves. Our preference is to initiate chemoprophylaxis for prevention of venous thrombolic embolism beginning the day after surgery, in addition to mechanical prophylaxis with sequential compression devices and stockings. After an unstable injury to the hemipelvis (ie, APC type III), full weight bearing on the affected side should not commence until at least 8 weeks, with many surgeons waiting until 12 weeks.[23] For an injury that has only rotational instability (ie, LC type I), immediate weight bearing after stabilization with a low anterior two-pin external fixator is possible.[32] For a bilaterally unstable pelvic injury, mobilization of bed to chair for at least 8 weeks is necessary. Again, one must individualize to the injury pattern and quality of fixation and take into account other injuries that may affect weight bearing (ie, ipsilateral pilon fracture). It is intuitive to protect fixation of a joint with a ligamentous injury for a period of time to allow for soft-tissue healing, but the exact time necessary to achieve a critical level of healing is unclear.

## Long-term Sequelae

Long-term deficits after pelvic fracture are common. Fifty-six percent of women report dyspareunia after pelvic fracture.[44] Initial symphysis disruption, need for plate fixation of the symphysis, and final symphysis alignment >5 mm from anatomic are all associated with dyspareunia.[44] In addition, all of the patients with associated bladder rupture reported dyspareunia.[44] In another study, women with symphyseal disruption were at increased risk for sexual and excretory dysfunction, independent of overt pelvic organ injury, at 1 year after trauma.[45] With regard to childbirth, normal vaginal delivery is possible; however, the rate of cesarean section is higher than in the standard population (largely because of patient and obstetrician preference).[46]

Men are also prone to sexual dysfunction, with 61% of patients reporting limitation in sexual function and 19% continuing on to persistent erectile dysfunction.[47] Specifically, APC-type injuries and increasing age in men appear to be significant risk factors for erectile dysfunction, with some studies reporting rates as high as 90%.[48] However, fixation of an unstable pelvis does not change the results of impotence or neurologic injury incurred at the time of the trauma.

Compared to a reference population 2 years after surgically treated pelvic injuries, patients reported substantially lower quality of life in both physical and mental domains, even when radiologic and clinical outcomes were considered favorable.[49] Prevalence of chronic posttraumatic pelvic pain after AO class A, B, and C fractures is 38%, 67%, and 90%, respectively.[50] Regardless of fracture type or location, neurologic injury appears to be a universally accepted harbinger of poor outcome.[51] All patients should be counseled about these sequelae so that reversible deficits may be managed appropriately to help maximize outcome. It is important to counsel patients that pelvic pain is common and expected after almost all severe pelvic fractures.

## Summary

Most reduction and fixation of unstable pelvic fractures is performed with the patient in the supine position. Nonsurgical management is preferred for APC type I injuries. In an APC type IIa injury, the posterior SI ligaments are intact, and anterior fixation alone is typically sufficient. In an APC type IIb injury, the posterior SI ligaments are attenuated, which may contribute to more sagittal plane rotational instability of the hemipelvis. With >1 cm of displacement, supplementing the anterior fixation with posterior ring stabilization via an iliosacral screw is preferable. For APC type III injuries, anterior and posterior fixation is required as well as temporizing measures during resuscitation. Most patients with LC type I injury are treated nonsurgically. If open reduction is needed for an LC type II injury, the approach is governed by the size and position of the iliac fragment. Surgical treatment of LC type III injuries follows the same methods as those for LC and APC injuries. Surgical fixation is indicated in all VS injuries. Patients with unstable pelvic injuries combined with displaced acetabular fractures are almost always indicated for fixation because of inherent instability. Long-term deficits after pelvic fracture are common; the most common chronic problems relate to sexual dysfunction and pain.

## References

*Evidence-based Medicine:* Levels of evidence are described in the table of contents. In this article, references 3, 18, 32, 45, and 46 are level II studies. References 4, 9, 13, 24, 37, 41, 47, 49, and 50 are level III studies. References 17, 22, 28, 33-36, and 43 are level IV studies. References 10, 11, and 40 are level V expert opinion.

References printed in **bold type** are those published within the past 5 years.


1. **Gardner MJ, Krieg JC, Simpson TS, Bottlang M: Displacement after simulated pelvic ring injuries: A cadaveric model of recoil. *J Trauma* 2010;68(1):159-165.**

2. **Suzuki T, Morgan SJ, Smith WR, Stahel PF, Flierl MA, Hak DJ: Stress radiograph to detect true extent of symphyseal disruption in presumed anteroposterior compression type I pelvic injuries. *J Trauma* 2010;69(4):880-885.**

3. **Sagi HC, Coniglione FM, Stanford JH: Examination under anesthetic for occult pelvic ring instability. *J Orthop Trauma* 2011;25(9):529-536.**

4. Siegel J, Templeman DC, Tornetta P III: Single-leg-stance radiographs in the diagnosis of pelvic instability. *J Bone Joint Surg Am* 2008;90(10):2119-2125.

5. Matta JM: Indications for anterior fixation of pelvic fractures. *Clin Orthop Relat Res* 1996;329:88-96.

6. Tornetta P III, Dickson K, Matta JM: Outcome of rotationally unstable pelvic ring injuries treated operatively. *Clin Orthop Relat Res* 1996;329:147-151.

7. **Van Loon P, Kuhn S, Hofmann A, Hessmann MH, Rommens PM: Radiological analysis, operative management and functional outcome of open book pelvic lesions: A 13-year cohort study. *Injury* 2011;42(10):1012-1019.**

8. **Kanakaris NK, Angoules AG, Nikolaou VS, Kontakis G, Giannoudis PV: Treatment and outcomes of pelvic malunions and nonunions: A systematic review. *Clin Orthop Relat Res* 2009;467(8):2112-2124.**

9. **Bruce B, Reilly M, Sims S: OTA highlight paper predicting future displacement of nonoperatively managed lateral compression sacral fractures: Can it be done? *J Orthop Trauma* 2011;25(9):523-527.**

10. **Cannada LK, Reinert CM: Case report: locked pubic symphysis: An open reduction technique. *Clin Orthop Relat Res* 2009;467(8):2192-2195.**

11. O'Toole RV, Sagebien C, Andersen RC, Nascone JW: Superior pubic ramus osteotomy to treat locked pubic symphysis: A case report. *J Bone Joint Surg Am* 2006;88(7):1609-1614.

12. Letournel E, Judet R, Elson R: *Fractures of the Acetabulum*, ed 2. Berlin, Germany, Springer-Verlag, 1993.

13. **Suzuki T, Smith WR, Hak DJ, et al: Combined injuries of the pelvis and acetabulum: Nature of a devastating dyad. *J Orthop Trauma* 2010;24(5):303-308.**

14. **Osgood GM, Manson TT, O'Toole RV, Turen CH: Combined pelvic ring disruption and acetabular fracture: Associated injury patterns in 40 patients. *J Orthop Trauma* 2013;27(5):243-247.**

15. **Sagi HC, Afsari A, Dziadosz D: The anterior intra-pelvic (modified rives-stoppa) approach for fixation of acetabular fractures. *J Orthop Trauma* 2010;24(5):263-270.**

16. **Cole PA, Gauger EM, Anavian J, Ly TV, Morgan RA, Heddings AA: Anterior pelvic external fixator versus subcutaneous internal fixator in the treatment of anterior ring pelvic fractures. *J Orthop Trauma* 2012;26(5):269-277.**

17. **Vaidya R, Colen R, Vigdorchik J, Tonnos F, Sethi A: Treatment of unstable pelvic ring injuries with an internal anterior fixator and posterior fixation: Initial clinical series. *J Orthop Trauma* 2012;26(1):1-8.**

18. Placzek R, Ruffer M, Deuretzbacher G, Heijens E, Meiss AL: The fixation strength of hydroxyapatite-coated Schanz screws and standard stainless steel Schanz screws in lower extremity lengthening: A comparison based on a new torque value index. The fixation index. *Arch Orthop Trauma Surg* 2006;126(6):369-373.

19. Moroni A, Cadossi M, Romagnoli M, Faldini C, Giannini S: A biomechanical and histological analysis of standard versus hydroxyapatite-coated pins for external fixation. *J Biomed Mater Res B Appl Biomater* 2008;86(2):417-421.

20. Haidukewych GJ, Kumar S, Prpa B: Placement of half-pins for supra-acetabular external fixation: An anatomic study. *Clin Orthop Relat Res* 2003;411:269-273.

21. Carlson DA, Scheid DK, Maar DC, Baele JR, Kaehr DM: Safe placement of S1 and S2 iliosacral screws: The "vestibule" concept. *J Orthop Trauma* 2000;14(4):264-269.

22. Routt ML Jr, Kregor PJ, Simonian PT, Mayo KA: Early results of percutaneous iliosacral screws placed with the patient in the supine position. *J Orthop Trauma* 1995;9(3):207-214.

23. Tile M, Helfet DL, Kellam JF: *Fractures of the Pelvis and Acetabulum*, ed 3. Philadelphia, PA, Lippincott Williams & Wilkins, 2003.

24. Sagi HC, Papp S: Comparative radiographic and clinical outcome of two-hole and multi-hole symphyseal

plating. *J Orthop Trauma* 2008;22(6): 373-378.

25. **Moed BR, Grimshaw CS, Segina DN: Failure of locked design-specific plate fixation of the pubic symphysis: A report of six cases. *J Orthop Trauma* 2012; 26(7):e71-e75.**

26. **Grimshaw CS, Bledsoe JG, Moed BR: Locked versus standard unlocked plating of the pubic symphysis: A cadaver biomechanical study. *J Orthop Trauma* 2012;26(7):402-406.**

27. Mullis BH, Sagi HC: Minimum 1-year follow-up for patients with vertical shear sacroiliac joint dislocations treated with iliosacral screws: Does joint ankylosis or anatomic reduction contribute to functional outcome? *J Orthop Trauma* 2008;22(5):293-298.

28. **Gardner MJ, Parada S, Chip Routt ML Jr: Internal rotation and taping of the lower extremities for closed pelvic reduction. *J Orthop Trauma* 2009;23(5): 361-364.**

29. Matta JM, Yerasimides JG: Table-skeletal fixation as an adjunct to pelvic ring reduction. *J Orthop Trauma* 2007; 21(9):647-656.

30. **Ayvaz M, Çağlar O, Yılmaz G, Güvendik GI, Acaroğlu RE: Long-term outcome and quality of life of patients with unstable pelvic fractures treated by closed reduction and percutaneous fixation. *Ulus Travma Acil Cerrahi Derg* 2011;17(3):261-266.**

31. **Gras F, Marintschev I, Wilharm A, Klos K, Mückley T, Hofmann GO: 2D-fluoroscopic navigated percutaneous screw fixation of pelvic ring injuries: A case series. *BMC Musculoskelet Disord* 2010;11:153.**

32. Bellabarba C, Ricci WM, Bolhofner BR: Distraction external fixation in lateral compression pelvic fractures. *J Orthop Trauma* 2000;14(7):475-482.

33. **Evans AR, Routt ML Jr, Nork SE, Krieg JC: Oblique distraction external pelvic fixation. *J Orthop Trauma* 2012;26(5): 322-326.**

34. Borrelli J Jr, Koval KJ, Helfet DL: Operative stabilization of fracture dislocations of the sacroiliac joint. *Clin Orthop Relat Res* 1996;329:141-146.

35. Day AC, Kinmont C, Bircher MD, Kumar S: Crescent fracture-dislocation of the sacroiliac joint: A functional classification. *J Bone Joint Surg Br* 2007; 89(5):651-658.

36. **Osterhoff G, Ossendorf C, Wanner GA, Simmen HP, Werner CM: Posterior screw fixation in rotationally unstable pelvic ring injuries. *Injury* 2011;42(10): 992-996.**

37. Griffin DR, Starr AJ, Reinert CM, Jones AL, Whitlock S: Vertically unstable pelvic fractures fixed with percutaneous iliosacral screws: Does posterior injury pattern predict fixation failure? *J Orthop Trauma* 2003;17(6):399-405.

38. **Tabaie SA, Bledsoe JG, Moed BR: Biomechanical comparison of standard iliosacral screw fixation to transsacral locked screw fixation in a Type C - Zone II pelvic fracture model. *J Orthop Trauma* 2012; Oct 30 [Epub ahead of print].**

39. **Moed BR, Whiting DR: Locked transsacral screw fixation of bilateral injuries of the posterior pelvic ring: Initial clinical series. *J Orthop Trauma* 2010;24(10):616-621.**

40. **Sagi HC: Technical aspects and recommended treatment algorithms in triangular osteosynthesis and spinopelvic fixation for vertical shear transforaminal sacral fractures. *J Orthop Trauma* 2009; 23(5):354-360.**

41. Schildhauer TA, Josten C, Muhr G: Triangular osteosynthesis of vertically unstable sacrum fractures: A new concept allowing early weight-bearing. *J Orthop Trauma* 1998;12(5):307-314.

42. Schildhauer TA, Ledoux WR, Chapman JR, Henley MB, Tencer AF, Routt ML Jr: Triangular osteosynthesis and iliosacral screw fixation for unstable sacral fractures: A cadaveric and biomechanical evaluation under cyclic loads. *J Orthop Trauma* 2003;17(1):22-31.

43. **Sagi HC, Militano U, Caron T, Lindvall E: A comprehensive analysis with minimum 1-year follow-up of vertically unstable transforaminal sacral fractures treated with triangular osteosynthesis. *J Orthop Trauma* 2009;23(5):313-321.**

44. **Vallier HA, Cureton BA, Schubeck D: Pelvic ring injury is associated with sexual dysfunction in women. *J Orthop Trauma* 2012;26(5):308-313.**

45. Wright JL, Nathens AB, Rivara FP, MacKenzie EJ, Wessells H: Specific fracture configurations predict sexual and excretory dysfunction in men and women 1 year after pelvic fracture. *J Urol* 2006;176(4 pt 1):1540-1545.

46. **Vallier HA, Cureton BA, Schubeck D: Pregnancy outcomes after pelvic ring injury. *J Orthop Trauma* 2012;26(5): 302-307.**

47. Metze M, Tiemann AH, Josten C: Male sexual dysfunction after pelvic fracture. *J Trauma* 2007;63(2):394-401.

48. **Collinge CA, Archdeacon MT, LeBus G: Saddle-horn injury of the pelvis: The injury, its outcomes, and associated male sexual dysfunction. *J Bone Joint Surg Am* 2009;91(7):1630-1636.**

49. **Borg T, Berg P, Fugl-Meyer K, Larsson S: Health-related quality of life and life satisfaction in patients following surgically treated pelvic ring fractures: A prospective observational study with two years follow-up. *Injury* 2010;41(4):400-404.**

50. **Gerbershagen HJ, Dagtekin O, Isenberg J, et al: Chronic pain and disability after pelvic and acetabular fractures: Assessment with the Mainz Pain Staging System. *J Trauma* 2010;69(1):128-136.**

51. Suzuki T, Shindo M, Soma K, et al: Long-term functional outcome after unstable pelvic ring fracture. *J Trauma* 2007;63(4):884-888.