Table-Skeletal Fixation as an Adjunct to Pelvic Ring Reduction

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Abstract: The reduction of displaced pelvic ring injuries remains a technical challenge, especially when treatment is delayed. A pelvic frame (Orthopaedic Systems Inc, Union City, California) provides a means of external skeletal fixation, rigidly stabilizing the intact hemipelvis to the operating room table. The fractured and displaced fragments can then be manipulated around the securely fixed uninjured hemipelvis, allowing the application of more directions and magnitudes of force for reduction maneuvers than allowed by the traditional means of pelvic reduction. The surgical technique and a case each of an acute fracture and pelvic nonunion/malunion are presented.

Key Words: pelvic ring injury, pelvic malunion, pelvic nonunion, pelvis fracture reduction

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INTRODUCTION

Treatment of the unstable pelvic ring is optimized by accurate reduction of the fracture before proceeding with stable fixation. Reduction of the pelvic ring is sometimes difficult because of inexperience, lack of understanding of the injury, and inability to apply force in the vectors necessary for reduction. Cranially (vertically) displaced and unstable fractures of the pelvic ring are especially at risk for failure of reduction and poor outcomes.

A basic principle of fracture fixation in a cranially unstable pelvic ring injury is reduction and fixation of the posterior pelvic ring first.9 It is a common misconception that fixation of the anterior pelvic ring will bring the posterior ring into its anatomic position. More commonly, the anterior ring will be partially reduced and the posterior hemipelvis will remain displaced cranially and anteriorly (Figs. 1 and 2).

In our experience, reducing the cranially displaced posterior pelvic ring remains a difficult procedure. Large amounts of caudad traction may be required, exceeding the strength of the strongest assistant. Skeletal traction applied with weights or an orthopaedic table can create large forces. As important as a means to apply force to the displaced hemipelvis, however, is a method to stabilize the opposite intact side.

Although the frictional forces generated by the weight of the patient on the operating table provide some resistance to traction, the forces necessary to reduce the pelvic ring can be greater than this, resulting in the patient being pulled distally. The classical orthopaedic table solution is the perineal post. The pelvis, however, can rotate around the post in response to unilateral traction. Additionally the post may aggravate anterior pelvic ring deformity with pressure against mobile ramus fractures and/or resist the closure of a dislocated symphysis.

We describe a technique to stabilize the intact hemipelvis and reduce the cranially displaced hemipelvis without the perineal post on an orthopaedic fracture table. Since 2002 the authors have used this technique regularly and successfully for acute fractures and reconstructions of malunited fractures of the pelvic ring. With this technique strong caudad traction can be applied to the isolated hemipelvis without moving the contralateral side and avoiding the potential anterior deforming effects of a perineal post.

SURGICAL TECHNIQUE

The pelvic frame (Well Hip Fixation Frame, OSI, Union City, California) is a simple metal frame that attaches to the side of the PROfx (OSI) or Jackson orthopaedic tables (Fig. 3). There are 2 fixation bars at different levels compatible with 8- or 10-mm external fixation systems. The frame can be applied with the patient in either the prone or supine position, as described later (Figs. 4 and 5). In most acute cases, our protocol is to address the posterior pelvic injury first and in the prone position,9 with the injured leg in traction (Fig. 6). Prone positioning allows an open exposure should attempts at closed reduction fail. In cases of malunion or nonunion the anterior pelvis is mobilized with an anterior approach before repositioning the patient prone for the posterior ring mobilization, reduction, and fixation.7,9 We find the prone position facilitates placement of internal fixation of the posterior ring and aids optimal placement of percutaneously placed iliosacral screws.
A traction pin is placed in the distal femur on the side of the unstable hemipelvis. The patient is placed in a prone position on the orthopaedic fracture table with the affected leg attached to the table using the traction pin and boot (Fig. 6). The contralateral hip is prepped and a 6-mm fixateur pin is placed in the subtrochanteric region of the femur after predrilling with a 4.5-mm bit. Betadine-soaked gauze is then placed around the pin for a dressing because it will not be prepped within the operative field. The pelvic reduction frame is attached to the table in a position with the lower fixation bar at the level of the subtrochanteric pin. The pin is then attached to the frame using external fixateur parts (Synthes Large External Fixator/10 mm or Stryker Hoffman II Fixation Set/8 mm). The fixateur rods are triangulated to the frame for increased stability. It is important to place the fixateur clamp as close to the skin as possible to increase the overall stiffness of the construct. The posterior pelvis is then prepped and draped in usual fashion.

The posterior superior iliac spine of the unaffected hemipelvis is palpated and a 6-mm pin is placed. The drill is started on the posterior superior iliac spine angling lateral approximately 20 degrees in relation to the sagittal plane and slightly distal to achieve placement in the sciatic buttress. Fluoroscopy is used to verify position of the drill by rotating the image to parallel the drill bit, confirming good position (Fig. 8). The 6-mm pin is then placed in the predrilled hole to an appropriate depth. It is important to use a long pin (usually around 160–200 mm) and to verify the pin is fully contained in the pelvis. If the pin is short or in an inadequate section of bone, it is possible to pull out with heavy traction. An external fixateur bar of appropriate length is then selected to attach this pin to the upper-fixation bar of the pelvic reduction frame. Again, place the pin clamp as close to the skin as possible to increase the overall strength of the construct. The bar is placed through a hole cut in the drape where an unsterile assistant places the bar into the clamp attaching it to the frame. The hole in the drapes is sealed with...
a Steri-Drape (Fig. 9). It is important to tighten the clamp to the fixateur pin first in order to place the bar in appropriate tension. After the clamp on the pin is tightened, the assistant pulls the other end of the bar as the surgeon pushes to achieve tension on the hemipelvis. This preload will help prevent pelvic tilt when traction is applied to the contralateral side. At this point, the unaffected hemipelvis is securely attached to the orthopaedic table by 6-mm pins in the subtrochanteric femur and pelvis. The femoral pin prevents distal migration. The pelvic pin prevents rotation of the pelvis around the stabilized femoral head. Traction can now be applied through the orthopaedic table to the affected hemipelvis (Fig. 10).

Once the posterior ring is reduced by traction alone or by traction plus open application of bone clamps and fixation is

FIGURE 2. With anterior fixation in place, rotation occurs around the superior symphysis. This extension of the hemipelvis displaces the sacral ala in a superior and anterior direction.

FIGURE 4. With the patient prone, the fixateur pin in the femur is attached to the lower fixation bar of the frame. The fixateur bars are triangulated to increase strength of the construct. The pin placed in the posterior superior spine of the pelvis is attached to the upper fixation bar of the frame.

FIGURE 3. The Well Hip Fixation Frame is a basic metal frame compatible with 8- and 10-mm external fixation systems. There are 2 fixation bars at different levels. The clamps that attach the frame to the table are reversible so the same frame can be used for the right and left sides of the table.

FIGURE 5. With the patient supine, the femoral pin is placed and anchored to the lower fixation bar in the same manner as described for prone positioning. The pelvic pin is placed in the pelvis at the medius tubercle and advanced into the anterior pillar of the pelvis. This is attached to the upper fixation bar of the frame.
obtained, it is common to see the anterior ring in a reduced position. After fixation of the posterior pelvic ring, the pelvic reduction frame and traction pin are removed. The patient is then placed in a supine position for anterior pelvic ring fixation if necessary.

The frame can also be applied to the patient for treatment in the supine position if this is the surgeon’s preference. In some cases where the surgeon believes they can achieve a closed reduction of the posterior pelvic ring, it may be better to apply the frame to the patient in a supine position. In this case, the surgeon can fix the posterior and anterior pelvic ring without repositioning the patient. The patient is positioned supine on the table, and again the first fixateur pin is placed in the proximal femur and secured to the frame as described earlier. The second pin is placed at the medius tubercle and directed down the anterior pillar of the ilium in a distal, medial, and posterior direction. This pin is secured to the upper bar of the frame, similar to the situation with the patient prone.
ILLUSTRATIVE CASES

Case 1: Acute Fracture

A 34-year-old female fell while horseback riding. She was taken to a local hospital complaining of low back and groin pain. Anteroposterior (AP) and inlet/outlet radiographic views of the pelvis showed a left sacral fracture with sacroiliac joint dislocation and pubic symphysis dislocation (Fig. 11). The left hemipelvis was translated cranially approximately 2 cm. A left hip dislocation was reduced with the patient under conscious sedation. The patient was referred to our facility for definitive treatment of her pelvic ring injury.

The patient was taken to the operating room and administered general anesthesia. A distal femoral traction pin was placed and the patient was positioned prone. The unaffected, right hemipelvis was secured to the table with 6-mm pins placed in the subtrochanteric region of the femur and posterior superior iliac spine. External fixateur components were used to attach the pins to a frame on the table. Traction was applied to the left hemipelvis through the left distal femoral traction pin and a closed reduction was accomplished. A percutaneous transsacral screw was placed in an appropriate position holding the reduction.1 The wounds were closed and temporary fixateur pins were removed. The patient was turned to a supine position and an intraoperative radiograph was taken (Fig. 12). The anterior pelvic ring was nearly reduced after the posterior reduction and symphysal plating were performed (Fig. 13). She was allowed 30 pounds partial weightbearing on the left. Clinical examination revealed no neurologic injuries, and she was discharged on postoperative day number 4. At her 3-month follow-up appointment, she was having minimal discomfort and exercising regularly. Her gait was normal and radiographs showed no loss of reduction and fracture healing (Fig. 14).

Case 2: Pelvic Nonunion/Malunion

A 39-year-old man was involved in an off-road motorcycle accident on February 1, 2003. He initially was evaluated and found to have a left sacral fracture with symphysis pubis dislocation. The patient was originally placed in an external fixateur. Open treatment with dual plating of the symphysis followed by 2 percutaneous screw placements across the sacral fracture were performed on February 5, 2003. By May 19, there was evidence of posterior fixation failure with cranial migration of the hemipelvis and revision surgery was performed, exchanging the 2 iliosacral screws for 2 longer screws.

The patient was seen in our office on September 22, 2003 complaining of leg-length discrepancy, buttock pain, and problems with sitting. He worked as a commercial airline pilot and could not sit without leaning. At the time of injury he had a urethral injury that was repaired. He also had a foot drop and had lost the ability to obtain erection or ejaculation. Over the past few months, he had increasing buttock pain and clicking

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posteriorly. Radiographs in the office included AP pelvis, caudad, and cephalad views, which showed 20 mm of cephalad displacement of the sacral fracture on the cephalad view (Fig. 15). This is the deformity that typically occurs when the reduction is performed anteriorly and there is no posterior pelvic ring reduction. A computed tomography (CT) scan from the prior month demonstrated a sacral nonunion. After discussion with the patient, a corrective pelvic ring osteotomy was scheduled.

On October 2, 2003 the patient was taken to the operating room for a 3-stage pelvic reconstruction. The patient was placed in a supine position and administered general anesthetic. The lower abdomen incision was reopened and the symphysis plates were exposed. The plates were removed and the symphysis was mobilized. A urologist was present to place a suprapubic catheter to avoid instrumenting the urethra. The wound was irrigated and closed.

A traction pin was placed in the left distal femur and the patient was turned to a prone position for the second stage of the procedure. The pelvic frame was placed on the unaffected right hemipelvis as described in the technique earlier. A longitudinal incision was made just lateral to the posterior superior iliac spine on the left, and the sacral nonunion was exposed. The previous iliosacral screws and washers were removed. The nonunion site was visualized and found to be mobile. A second 6-mm pin was placed in the posterior superior iliac spine on the affected hemipelvis and a fixateur bar was placed between the 2 pins. A distraction device was then used to open the nonunion site for mobilization and preparation. Once the nonunion had been fully mobilized and vascular bleeding bone was seen, the distraction was removed and reduction was carried out. Traction was applied through the distal femoral pin and clamps were placed between the sacral lamina and posterior superior iliac spine. After a number

FIGURE 11. Case 1: Preoperative AP (A), inlet (B), and outlet (C) radiographs show a vertically unstable fracture dislocation of the left sacro-iliac joint. The left hemipelvis is displaced cranially.

FIGURE 12. An AP radiograph after Stage I of the procedure showed excellent reduction of the posterior pelvic ring and resultant reduction of the anterior ring. Commonly after reduction of the posterior pelvic ring, the anterior ring will appear greatly reduced.
of manipulations, satisfactory reduction was achieved. The sacral nonunion was then fixed with a transsacral screw placed across the nonunion, through the S1 vertebral body and into the ileum on the right. After this, the fixation was reinforced with a posterior sacral tension band plate. The wounds were irrigated and closed over drains. The pelvic frame was removed along with the traction pin in preparation for the third and final stage.

The patient was then rolled to a supine position and the lower abdomen incision was reopened. The symphysis was curetted to expose bleeding bone in preparation for fusion. An 8-hole plate was placed across the symphysis with 4 screws placed on either side. The incision was extended on 1 side to expose the internal iliac fossa for bone graft. A segment of cortex with underlying cancellous bone measuring about 2.5 cm by 5 cm was taken and placed on the posterior aspect of the symphysis. The residual gap in the symphysis was packed with cancellous bone and the graft was fixed to the posterior aspect of the symphysis with two 3.5-mm screws.\textsuperscript{10} The wound was irrigated and closed over a drain. Postoperative radiographs showed correction of the deformity (Fig. 16).

Postoperatively, the patient was allowed 30 pounds partial weightbearing on the left, full weightbearing on the right for wheelchair transfers, and very limited ambulation. The patient was discharged from the hospital on postoperative day 10 with the suprapubic catheter in place. The catheter was removed at 2 weeks after a follow-up cystogram. Ambulation was limited for 8 weeks, then advanced to weightbearing as tolerated. A follow-up examination at 10 weeks showed maintenance of the reduction (Fig. 17).

**DISCUSSION**

Most authors agree that nonoperative management of unstable pelvic ring injuries yields poor results.\textsuperscript{1,4,5,8,12}
Although there is published controversy regarding the importance of an anatomic reduction of various posterior pelvic fracture patterns,3,5,6,11 most studies have related the quality of the reduction of the posterior pelvis to patient outcome. Our indications for reduction and fixation are the presence of instability and/or deformity, and our surgical goal remains to achieve and maintain an anatomic reduction, by closed means if possible but with open techniques if necessary. Open or closed, we feel the main technical difficulty in pelvic fracture surgery remains achieving reduction of the pelvic ring.

**FIGURE 15.** Case 2: 4 months after the revision fixation, radiographs show a malreduced pelvic ring. The AP (A) shows an obvious discrepancy in the level of the right and left ischium. As demonstrated with the sawbones pelvis in Figure 1, the inlet view (B) shows a relatively symmetric pelvic ring, whereas the outlet view (C) shows the cranial displacement of the left hemipelvis. D, A CT scan shows nonunion of the left sacral fracture.

**FIGURE 16.** Postoperative AP (A), inlet (B), and outlet (C) films show correction of the deformity. The left hemipelvis, which was displaced cephalad, has been returned to a more anatomic position, as evident by the level of the ischium (A).
Reduction by bone clamps is limited by available sites of clamp application, and a clamp’s action can only decrease the distance between 2 points along the line between these points. Similarly, a skeletal distractor can only increase the distance between 2 points. Application of extrinsic force to a displaced segment of the pelvis by manual or mechanical means is not limited in direction; however, large magnitudes of force can drag or push the patient across the operating table.

The table–skeletal pelvic fixation frame was devised as a method of securing the normal side of the pelvis to the table. The goal of stabilization was to resist movement of the intact side of the pelvis as extrinsic reduction forces were applied. The stabilization method was designed to resist proximal–distal, medial–lateral, and rotational displacement. The concept of fixation with 2 pins was chosen for simplicity and to limit the number of well-side incisions; with use, the 2 pin technique has proved satisfactory. In choosing the location for the 2 pins, several factors were considered to maximize stability of the construct: solidity of bone in the pelvis and femur, closeness of the bone to the skin (desirable), and the distance between the 2 pins (greater distance controls rotation better). These principles of pin location are well-accepted in skeletal external fixation.

The primary use of this stabilization to date has been to resist distal translation and coronal plane rotation when distal femoral skeletal traction or boot traction is applied to the opposite unstable side. As we began use of the device we recognized the potential benefit and potential hazard of the large forces that could be obtained. The obvious benefit is correction of cranial displacement of the unstable hemipelvis in an acute or old injury with the simple turn of a crank. Additionally the pelvis would remain stable while fixation was applied—an advantage over human-held “joy sticks.” The obvious potential dangers were pin cut out associated with large forces or nerve injury from overdistraction. As opposed to a perineal post, however, the pudendal nerve is not endangered. As traction is applied, therefore, we have been careful not to overdistact by monitoring with x-ray and have also monitored the pin sites visually and with x-ray for any evidence of cut out. From the beginning we did not expect the pin in the dense proximal femoral bone to be a problem and it has not been. The pelvic pin was more worrisome, however. We are happy to note that cut out of the pelvic pin has also not been observed, even in older patients. Our explanation for this is that the ex fix clamp is very close to the subcutaneous bony entrance point and that the clamp rigidly fixes the angle of the pin to the ex fix bar. This fixed angle prevents rotational motion of the pin and “levering out.” For this interface to fail, the entire length of the pin would need to cut sideways through the bone. To date we have not identified any complications specific to the frame use.

This pelvic frame has increased our possibility of obtaining a closed reduction of the pelvic ring. When closed reduction fails, we feel this construct almost always helps as an adjunct to clamp application during open reduction. In our experience, some sacral fractures in the past have been extremely difficult and sometimes impossible to reduce even open because of limited areas for clamp application. Another problem area with sometimes impossible reductions has been old fractures and malunions. The pelvic frame has been a dramatic improvement for us in our ability to solve these problem reductions. We have not, however, found this technique to be a panacea. A diastasis of the posterior injury is often not corrected with distal traction, and direct pressure on the hemipelvis, clamps, and/or screw compression must often be combined. An initial anterior or posterior displacement of the posterior ring may need to also be addressed separately with clamps or a “gravity help” by choosing either the prone or supine position for reduction.

An anterior widening of the symphysis tends to close with the applied distal traction. In more than 1 case, however, we observed the initially wide symphysis to “overclose” and go to an overriding locked condition. A lateral manual pull on the proximal thigh or a pull on a pin placed in the proximal femur has been effective in correcting this. It is therefore important to observe both the anterior and posterior pelvic ring displacements with x-ray during the reduction.

The current frame design is simple, is relatively inexpensive, and attaches to operating room tables that are already present in the majority of trauma centers.

We believe that table–skeletal fixation opens the door for devising a variety of methods in which the unstable hemipelvis can be effectively pushed, pulled, or rotated by extrinsic forces.

REFERENCES


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