Adam J. Starr, MD
Kelly A. Lefaivre, MD†
Charles M. Reinert, MD

Minimally Invasive Reduction of Pelvic Fractures Using the Starr Pelvic Reduction Frame

Department of Orthopaedic Surgery
University of Texas Southwestern Medical Center
Dallas, Texas

† Department of Orthopaedic Surgery
University of British Columbia
Vancouver, British Columbia, Canada

Introduction

The goal of surgical treatment of pelvic ring disruptions is to restore normal alignment[1]. Direct manipulation of fracture fragments makes reduction easier. However, open reduction and internal fixation of the posterior pelvic ring carries a fairly high wound complication rate[2]. Percutaneous methods of reduction and stabilization carry a far lower wound complication rate[1], but achieving an adequate re-alignment of the pelvic ring with minimally invasive techniques is difficult. Previous authors have described reduction techniques including manual traction and manipulation[3], use of anterior external fixators[4], and skeletal traction to restore alignment of the pelvic ring[3,5]. Unfortunately, these methods are not uniformly successful. Manual traction on the injured side often causes the un-injured side to roll and deform, while anterior external fixation usually does little to improve the posterior ring in grossly unstable fractures. Previously described methods do little to allow isolation and control of individual fracture fragments. Most recently, however, Matta described the use of a pelvic frame that is affixed to the operating table, and then to the intact pelvis using steel pins, to act as an anchoring point to facilitate re-alignment of the displaced portion of the pelvis[6].

Pelvic reduction, whether done via open or closed methods, is an exercise in the application of force to correct fracture deformity. Fracture displacement is almost always multi-planar. Thus, it seems clear that what is needed is a mechanism which allows the surgeon to control and manipulate multiple fracture fragments in multiple planes. This paper describes the use of a pelvic reduction frame (Starr Frame LLC, Richardson, Texas) designed to give surgeons this ability.

Figure 1: *Draping*

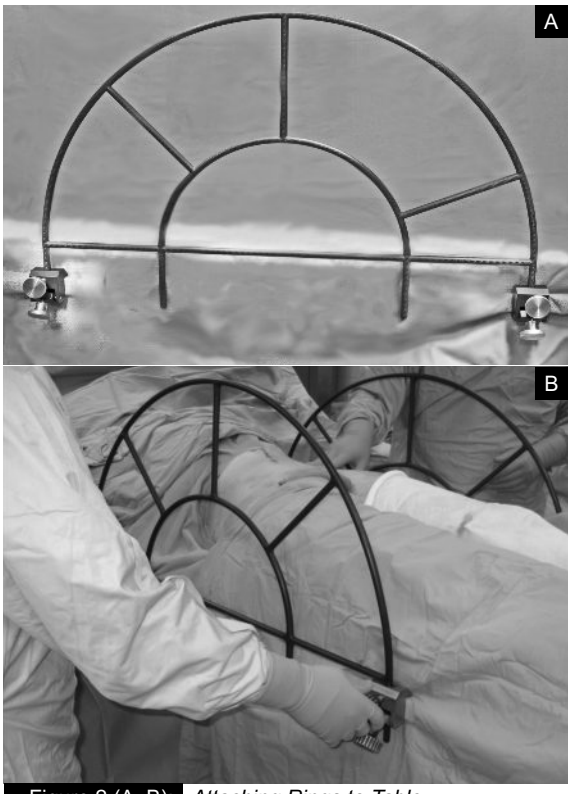

Figure 2 (A, B): *Attaching Rings to Table*

Surgical Technique

The patient is placed supine on a radiolucent operating table. Nitrous oxide anesthetic should not be used as the gas may enter the bowel lumen and obscure bony landmarks such as the sacral neural foraminae. The lower abdomen and affected hip are draped free. The bony landmarks of the anterior pelvic ring must be accessible. The leg ipsilateral to the pelvic ring disruption must be included in the sterile field to allow for traction, if necessary. If both sides of the posterior pelvic ring are displaced cephalad, both legs should be draped free to allow for bilateral traction (*Figure 1*).

Figure 3: *Table clamp*

Department of Orthopaedic Surgery, University of Texas Southwestern Medical Center, Dallas, Texas

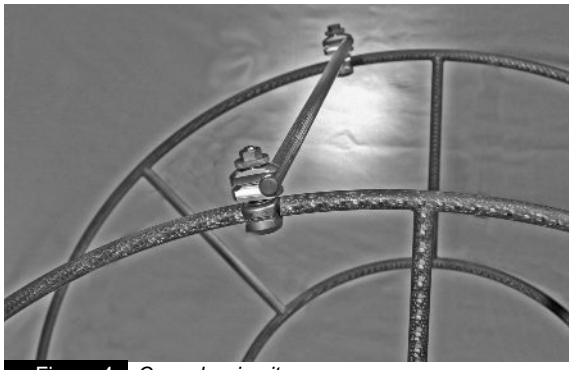

Figure 4: *Cross bar in situ*

Figure 5: *supra-acetabular pin in place, starting to place LC-2 pin*

Figure 6: *Anchoring pins in place*

Figure 7: *Pelvic Reduction Tools*

Affixing the frame to the table

Once the patient is draped, the two rings of the pelvic reduction frame (*Figure 2*) are affixed to the table using specially designed clamps (*Figure 3*). The cephalad clamps should be placed as far proximally as possible, near the axilla. Two or three long carbon fiber rods are then used to connect the left and right rings. Placement of these long rods increases the rigidity of the frame construct, forming a kind of box over the patient's pelvis (*Figure 4*).

Anchoring the patient to the frame

In general, the un-injured side of the pelvic ring (or least injured side) is anchored to the table via the frame, as follows. Half pins are percutaneously placed into the un-injured side, usually along the pathway employed for LC – 2 screws[7], the anterior inferior iliac spine (AIIS) to posterior inferior iliac spine (PIIS) pathway (*Figure 5*), and transversely above the acetabulum (*Figure 6*). These pins are affixed to the ring of the pelvic frame using standard external fixator clamps. More pins can be placed if needed, but two pins usually suffice to hold the un-injured side in place.

Reduction and fixation overview

Once the patient is anchored to the operating table, reduction begins. Reduction is done in a step-wise manner, in sequence. Affixing the reduction pins or tools (Figure 7) to the frame can hold correction at each step, so that multi-planar assessment of the alignment can be done fluoroscopically. In this way, re-alignment of the displaced pelvis becomes a measured, controlled process. Once reduction is judged adequate, fixation can proceed using cannulated screws or symphyseal plates. The pelvic reduction frame simplifies screw placement, since it allows fixation of a reduced fracture *in situ*, with no need for continuous reduction effort on the part of the surgical team.

1. Correction of cephalad displacement

Once the un-injured side has been anchored into place, cephalad displacement of the injured side can be corrected using leg traction. A tibial or femoral traction pin may be attached to the traction apparatus present on the fracture table. Elevation or depression of the angle of pull may be necessary to counteract the patient's deformity. Skeletal traction is a powerful method to reduce cephalad displacement. Maintenance of the position of the un-injured side of the pelvic ring using the frame allows the surgeon precise correction of cephalad displacement of the injured portion (*Figure 8*).

† Department of Orthopaedic Surgery, University of British Columbia, Vancouver, British Columbia, Canada

Skeletal traction also tends to pull the hemi-pelvis anteriorly. In some instances this is beneficial, as cephalad displacement often combines with displacement dorsally. In other cases, however, cephalad displacement occurs in isolation. In these instances correction may be obtained using a half pin placed in the iliac wing on the injured side (*Figure 9*). Caudal pressure on this pin can be used to gradually correct displacement, and the correction can be held in place using standard external fixator clamps affixed to the pelvic reduction frame.

2. Correction of rotational displacement

A) Correction of coronal plane displacement
For displacement in the coronal plane (best seen on the pelvic inlet) traction provides some reduction dependent on the degree of knee flexion. In addition, the LC-2 pin is in plane to fine-tune this reduction, using a t-handled device to pull the displaced hemi-pelvis forward. Once reduction is obtained, the pin is locked to the frame. Fluoroscopy of the reduction maneuver in this plane is seen in *Figure 10*.
B) Correction of sagittal plane displacement
Widening of the sacro-iliac joint can be corrected by applying pressure to the iliac wing just anterior to the joint, using a ball-spike pusher or a half pin (*Figure 11*). The correction tool should be placed so as not to interfere with placement of iliosacral screws. Iliosacral screws themselves can also act as reduction aids, with compression furthered through the use of washers (*Figure 12*).

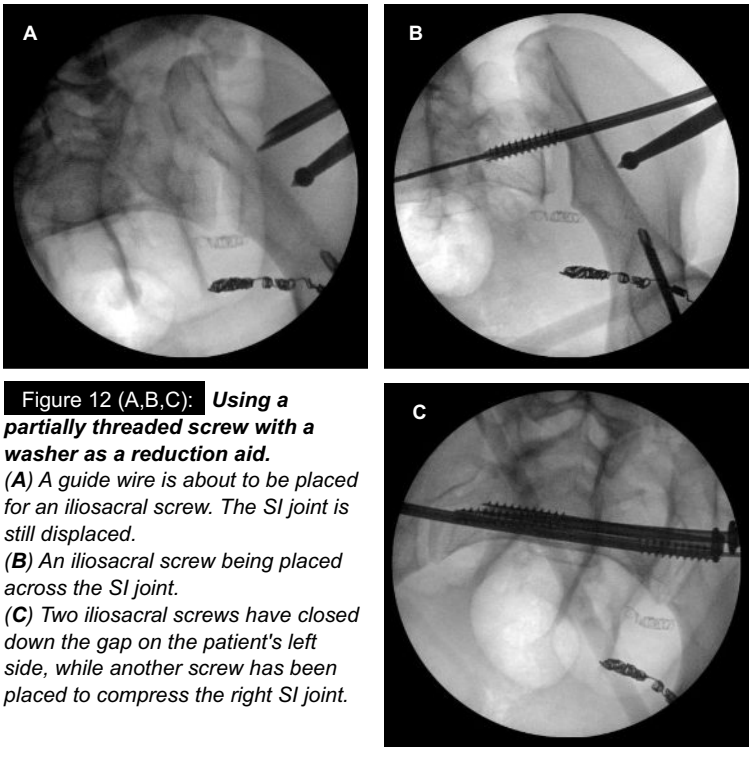

Figure 12 (A,B,C): ***Using a partially threaded screw with a washer as a reduction aid.***
*(**A**) A guide wire is about to be placed for an iliosacral screw. The SI joint is still displaced.*
*(**B**) An iliosacral screw being placed across the SI joint.*
*(**C**) Two iliosacral screws have closed down the gap on the patient's left side, while another screw has been placed to compress the right SI joint.*

Figure 8: *Leg traction in place*

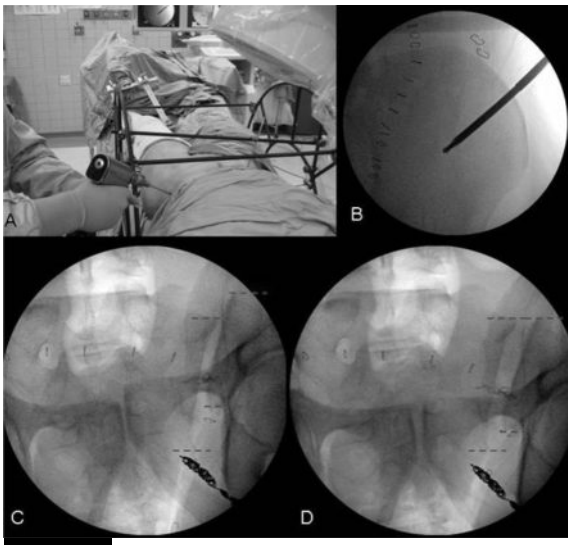

Figure 9: *reduction of vertical displacement.*
(A) Placement of iliac crest pin
(B) Fluoroscopy of iliac crest pin
(C) Vertical displacement seen on outlet view of the SI joint
(D)Post reduction maneuver

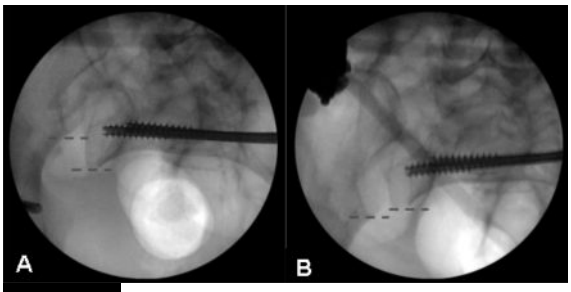

Figure 10: *Reduction in the Coronal Plane*

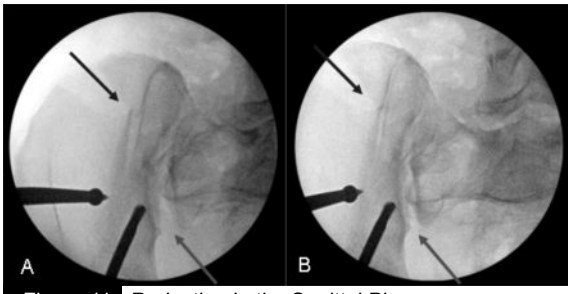

Figure 11: *Reduction in the Sagittal Plane*

Department of Orthopaedic Surgery, University of Texas Southwestern Medical Center, Dallas, Texas

Example Cases

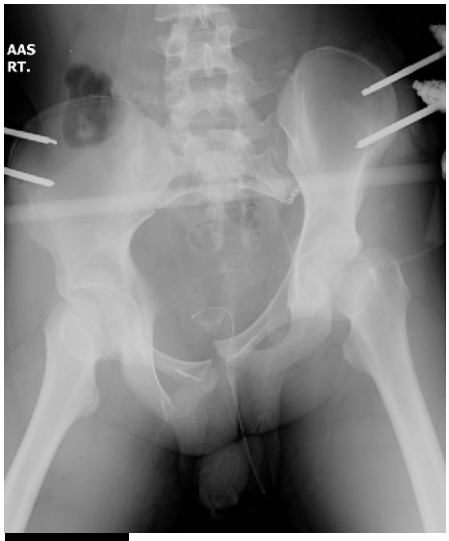

Figure 13: ***Case 1*** *Post-external fixator*

Case 1: *Vertical Shear Pelvic Ring Disruption*

A healthy 18 year old male was admitted to our institution after being struck by an automobile. The patient was demodynamically unstable and underwent angiographic embolization of a bleeding pelvic vessel. The patient was then brought to the operating room for other open musculoskeletal injuries, and a temporizing external fixator was placed at that time. In *Figure 13*, the displacement of the left sacroiliac joint in the external fixator is seen.

Chest injuries delayed definitive pelvic surgery for nine days. The patient was placed on the radiolucent table, and his injured extremity was draped free as previously described. Two stabilization pins were placed in the well side of the pelvis. On the injured side, leg traction was used, followed by an iliac wing pin to reduce the cephalad displacement, and an AP supra-acetabular pin was placed to reduce the dorsal displacement of the ilium. With the pelvis reduced, two iliosacral screws were placed. Because of the condition of the patient's skin anteriorly, a decision was made to leave the pins in place for an external fixator. Post-operative films are seen in *Figure 14*.

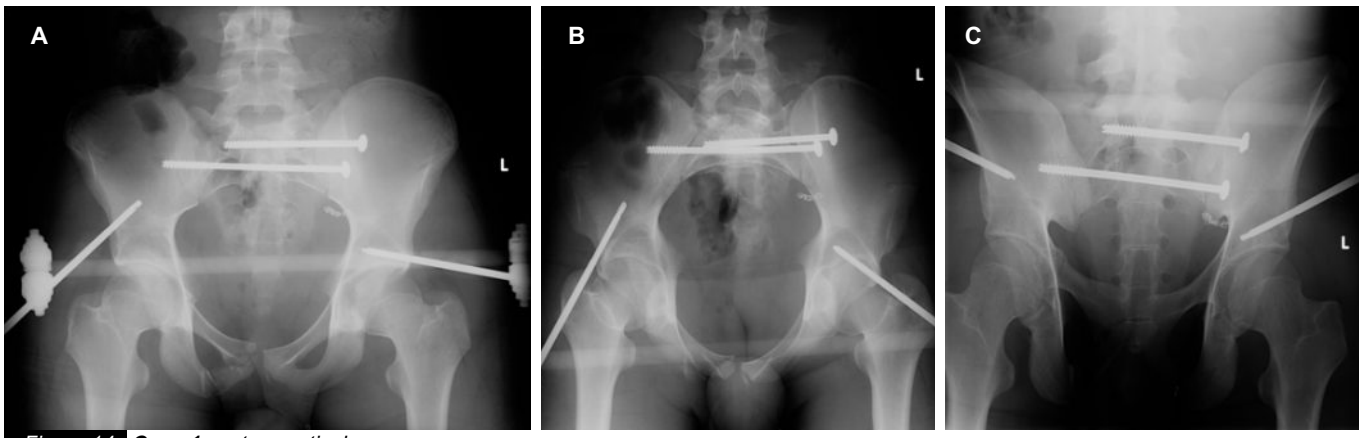

Figure 14: ***Case 1*** *post-operatively*

Example Case 2: *Bilateral Young and Burgess APC 3 Pelvic Ring Disruption*

Case 2 is a thirty-two year old male, also otherwise healthy. He and a fellow construction worker were struck by a sports utility vehicle. Injury films and CT scan in a pelvic binder clearly showed a left sided pelvic ring disruption, and right sided femur fracture. Imaging confirmed cephalad and dorsal displacement of the left hemi-pelvis, a symphysis disruption, and a left Nakatani 3 superior pubic ramus fracture[8] (*Figure 15*).

This patient was brought to the operating room on the day of injury for retrograde intramedullary nailing of his right femur, and a left skeletal traction pin was placed. The patient was then sent back to the surgical intensive care unit, where he remained intubated and recovering from lung contusions bilaterally. In discussions with the Trauma Team, a decision was made to bring the patient back to the operating room on post-injury day 5.

The patient was placed on the radiolucent table, and preliminary fluoroscopy was performed. We were surprised to find the right hemi pelvis significantly dorsally displaced, not uninjured and stable. We therefore prepped both lower extremities free, and set the bed up for bilateral traction.

† Department of Orthopaedic Surgery, University of British Columbia, Vancouver, British Columbia, Canada

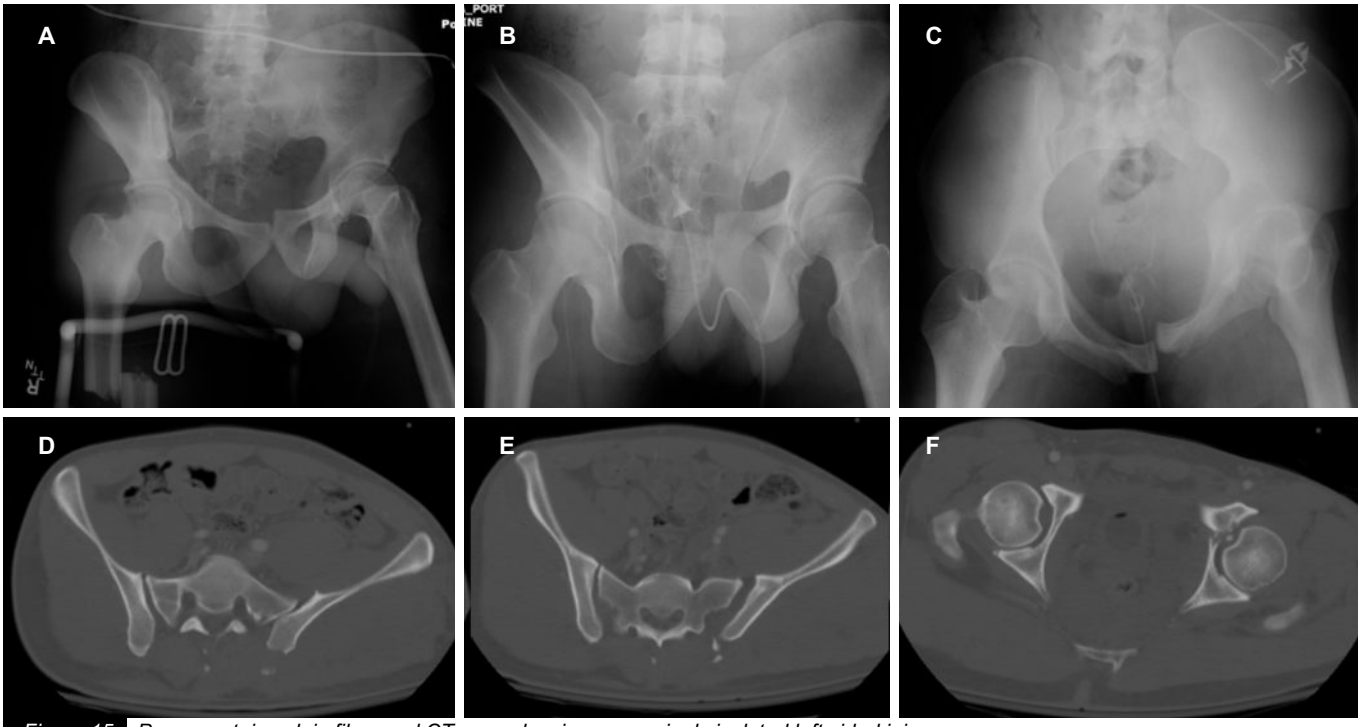

Figure 15: Pre-operataive plain films and CT scan showing a seemingly isolated left sided injury

The patient was placed on the radiolucent table, and preliminary fluoroscopy was performed. We were surprised to find the right hemi pelvis significantly dorsally displaced, not uninjured and stable. We therefore prepped both lower extremities free, and set the bed up for bilateral traction.

With no stable side of the pelvis to lock to the frame, the procedure is more complex. We elected to place two stabilization pins in the right side, which had not been in traction and was going to be more difficult to reduce. We then placed an AP supra-acetabular pin, iliac crest pin, a ball spike pusher, and leg traction on the left side (*Figure 16*). Once the left hemi-pelvis was reduced, we placed two iliosacral screws, into the second and third sacral segments because of first segment dysmorphism. With the left side now stable, we locked it to the frame and began reduction maneuvers on the right side. With traction on the leg and AP supra-acetabular pin the dorsal displacement was reduced (*Figure 16*). Using a reamer and curved guide pin, a second iliosacral screw was then placed into the second sacral segment from ilium to ilium.

Because the patient had been febrile with an elevated white blood cell count, we elected not to perform an open reduction and internal fixation of the symphysis. We left the AP supra-acetabular pins in place as a temporary external fixator. The patient underwent plate fixation of the symphysis later. Post-operative films at the end of the second procedure are seen in *Figure 17*.

References

1. **Tile M. Fractures of the pelvis and acetabulum**, 3rd ed., Baltimore: *Williams & Wilkins*; 2003

2. Kellam J, R. McMurtry, D. Paley, **Tile M. The unstable pelvic fracture**, *Orthop Clin N Am* 18 (1987), pp. 25–41

3. 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*. 9 (3). p 207-14. 1995

4. Bellabarba C, Ricci WM, Bolhofner BR. **Distraction external fixation in lateral compression pelvic fractures**. *J Orthop Trauma*. 2006;20:S7-14.

Department of Orthopaedic Surgery, University of Texas Southwestern Medical Center, Dallas, Texas

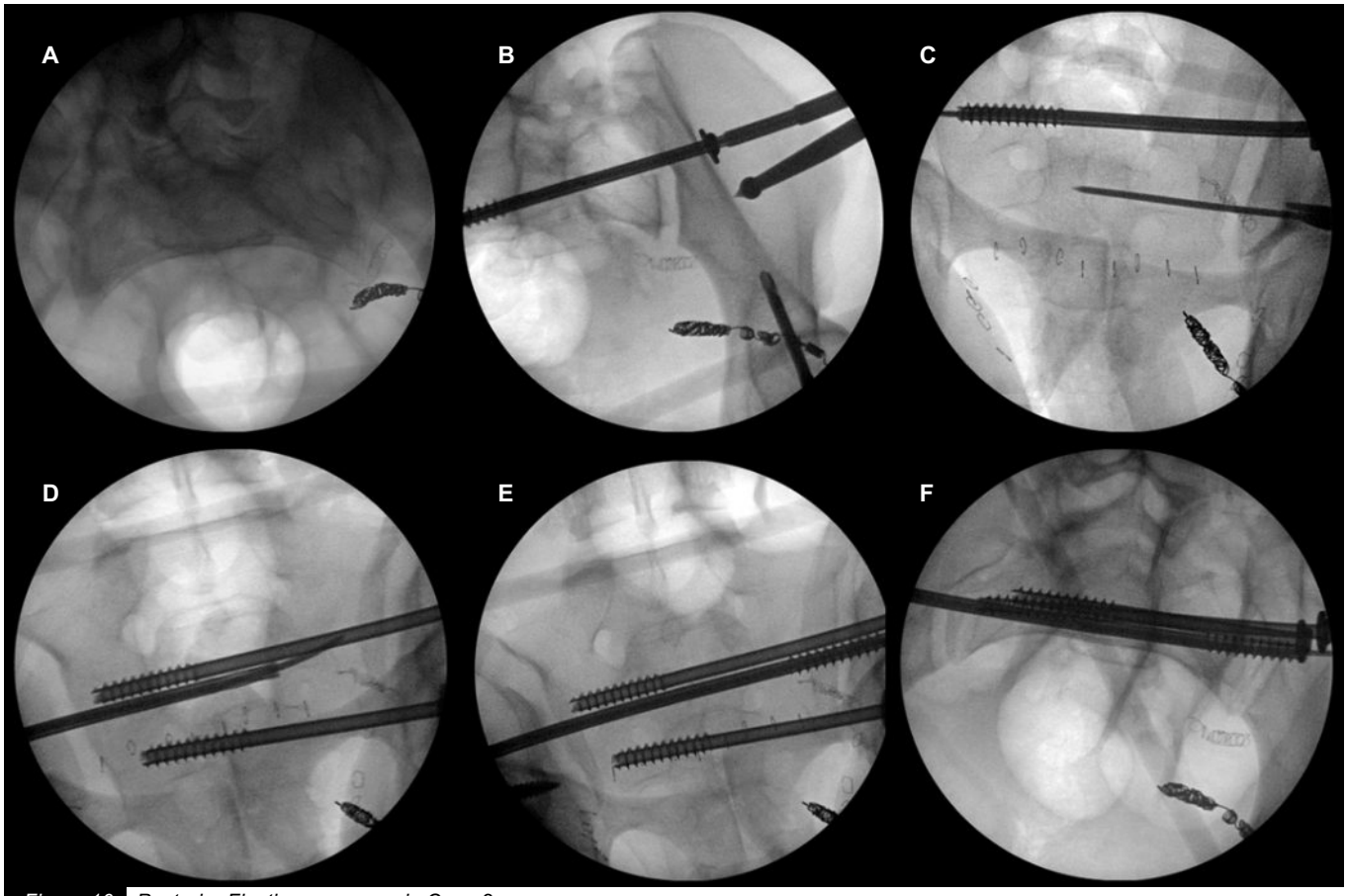

Figure 16: *Posterior Fixation sequence in Case 2*

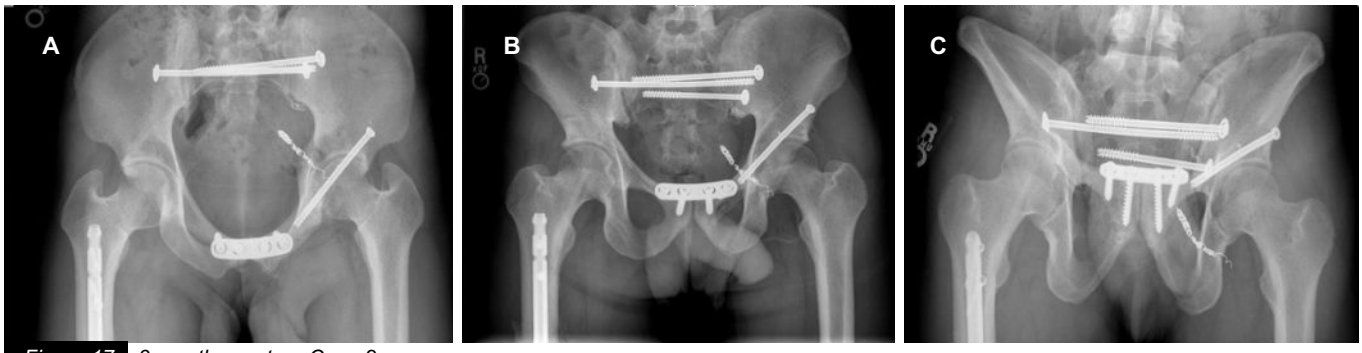

Figure 17: *3 months post-op Case 2*

5. Moed BR, Geer BL. **S2 iliosacral screw fixation for disruptions of the posterior pelvic ring: A report of 49 cases**. *J Orthop Trauma*. 2006;20:378-383.

6. Matta JM, Yerasimides JG. **Table-Skeletal Fixation as an Adjunct to Pelvic Ring Reduction**. *J Orthop Trauma*. 2007;21:647-656.

7. Starr AJ, Walters JC, Harris RW, Reinert CM, Jones AL, **Percutaneous Screw Fixation of Fractures of the Iliac Wing and Fracture Dislocations of the Sacro-iliac Joint** (OTA types 61-B2.2 and 61-B2.3, or Young-Burgess "Lateral Compression Type II" Pelvic Fractures), *J Orthop Trauma*.16:116-23, 2002.

8. Starr AJ, Nakatani T, Reinert CM et al. **Superior Pubic Ramus Fractures Fixed With Percutaneous Screws: What Predicts Fixation Failure?** *J Orthop Trauma*. Feb 2008. Vol 22 (2). 81-87

† Department of Orthopaedic Surgery, University of British Columbia, Vancouver, British Columbia, Canada

Adam J. Starr, MD
University of Texas Southwestern Medical Center
Associate Professor
Department of Orthopaedic Surgery
5323 Harry Hines Blvd.
Dallas, TX 75390-8870
Telephone: 214-648-6428
Fax: 214-648-3008
Email: adam.starr@utsouthwestern.edu