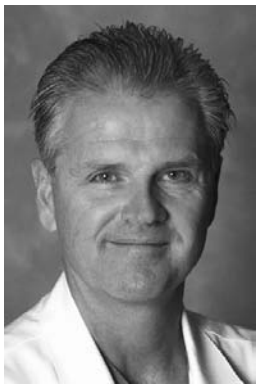

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Advanced Techniques of Minimally Invasive Pelvic Ring Fixation: Providing "Just Enough" Guidance to the Body's Regenerative Efforts

- The injured pelvis can regain the stability of its bony and ligamentous structures if they are held firmly in proper alignment during the healing process.
- Extensive, open surgical approaches have been associated with complications that interfere with healing.
- With minimally invasive yet stable methods for fracture fixation, the necessary restoration of anatomy can be achieved without the risks of open surgery.
- Accurate reduction and stable fixation of acetabular fractures avoids traction, allows early patient mobilization, and lowers the risk of post-traumatic hip arthritis.

High-energy traumatic events such as automobile crashes continue to cause significant pelvic ring injuries. Paramedical personnel and other primary responders to such accidents have refined their initial patient evaluation and resuscitation skills, which in turn have improved patient survivability. With increasing longevity and increasing activity, a growing number of older individuals are sustaining pelvic fractures. The management of pelvic instability in these patients can be complicated by poor bone quality and by concurrent health conditions affecting the heart, lungs, and urinary systems.

Due in large part to investigations at the University of Washington/ Harborview Medical Center, pelvic stabilization techniques have progressed far beyond prolonged bed-rest, body casting, and skeletal traction. The most recent advances are due to focused surgical experience and intra-operative fluoroscopic imaging techniques that enable fixation with minimal surgical exposure and dissection. For many surgeons, the pelvis is a difficult bone to understand because of its unique osseus morphology, anatomical variants, and topography. We have discovered several consistent pelvic osseus pathways that exist in most patients. These geometrically complex boney "tubes" are cancellous bone cylinders of different dimensions and orientations surrounded by cortical bone. These tubes accept and accommodate fixation devices that can be inserted using minimally invasive surgical techniques. Typically the fixation devices are large and long bone screws that span the fracture or ligamentous injury yet are contained safely and essentially completely within the bone tube. By stabilizing pelvic ring injuries, these percutaneously inserted implants decrease fracture related bleeding, provide patient comfort, prevent pelvic deformity, and allow mobilization while healing is taking place.

The pelvic osseus fixation pathways (OFP) are predictable and can be imaged in the operating room consistently. There are two consistent anterior pelvic OFP. One extends from the symphysis pubis to the supra-acetabular lateral iliac region and includes essentially the entire superior pubic ramus. The other anterior pelvic OFP includes the inferior pubic ramus extending from the symphysis pubis to the ischial tubersosity. In certain patients, both of these anterior pelvic OFP may span across the symphysis pubis. There are several mid-pelvic or iliac OFPs. One is deep and includes the anterior inferior iliac spine, pelvic brim, and posterior iliium. The second iliac OFP has two pathway options, extending from the iliac crest to either the supra-acetabular or quadrilateral surface areas. The third iliac OFP is superficial and extends along and within the iliac crest. The posterior pelvic OFP includes the lateral posterior ilium, sacroi-iliac joints, and upper two sacral vertebral segments. In some patients, the posterior pelvic OFP extends trans-iliac and trans-sacral spanning from one posterior illium, through the entire upper sacrum, and exiting the contralateral iliac cortical bone. Another pelvic OFP extends from the pelvic brim, remains intraosseus and posterior to the acetabulum, and

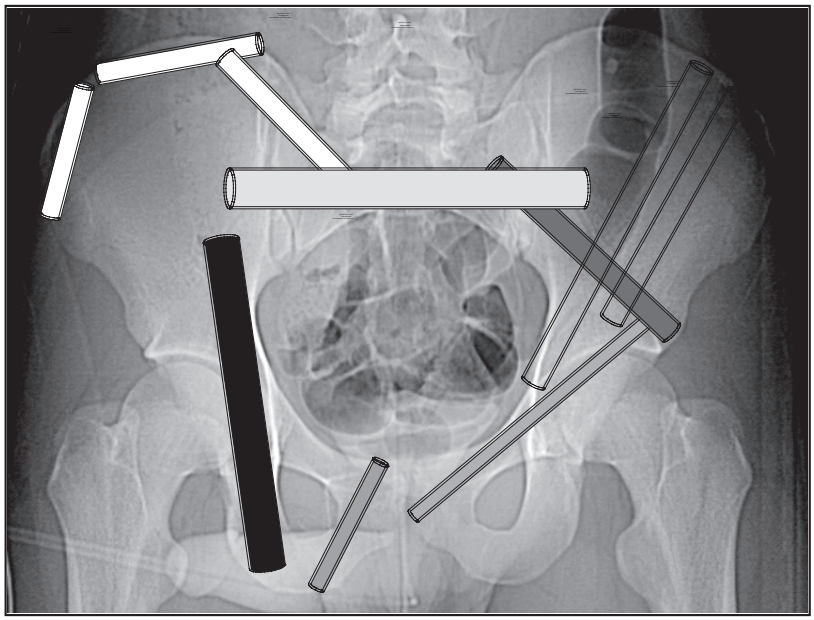


Figure 1: The common osseus fixation pathways (OFP) are represented as simple tubes superimposed on this anteroposterior pelvic radiograph. The white tubes represent the iliac crest areas. The black tube demonstrates the OFP posterior to the acetabulum from the ischium to the pelvic brim. The light grey OFP is the upper sacral area where iliosacral screws are applied. The dark grey tube represents the OFP extending from anterior inferior iliac spine to the posterior ilium. The empty tubes allow screw fixation from the iliac crest to either the supra-acetabular region or quadrilateral surface. The medium grey OFP extends from the pubic tubercle to the supra-acetabular area and is cranial and medial to the hip joint. The light medium grey OFP spans the inferior ramus from pubis to ischium. Both anterior pelvic OFPs can span the symphysis pubis if necessary for fixation.

ends at the ischial tuberosity. Upper sacral morphology is quite variable, so preoperative planning and intra-operative imagings are vital to safe and successful implant insertions.

Reduction of the pelvic ring injury sites prior to fixation is similarly critical to safe implant application within these OFPs. Mis-alignment of these pelvic OFPs narrows the safe region for implant placement and therefore increases the injury risk for surrounding anatomical structures such as viscera, arteries, veins, and nerve roots. Poor reduction allows residual fracture instability and may be related to higher implant failure and fracture nonunion rates.

At Harborview Medical Center, we have used early manipulative reduction and minimally invasive or percutaneous fixation techniques for twenty years with overall excellent results. These procedures can be routinely performed as a portion of patients' resuscitation efforts if necessary. The early pelvic reduction and stability decreases related hemorrhage, which has a positive impact on patient survival. Similarly, early reduction and fixation provide comfort and allow the patient to be mobilized into a chair or onto crutches depending on the overall patient condition and injury details. Using the numerous pelvic OFP, stable fixation implants can be inserted safely and through small stab incisions. These small surgical wounds decrease bleeding, scarring, and infection rates significantly. Such procedures can be performed expeditiously benefiting the patient by saving anesthesia and surgery time. Health care dollars are saved as the patients are rehabilitated quickly and efficiently, and can be discharged to home sooner. These patients can return to work within several weeks if their job situations will allow them to. The accurate reduction and stable fixation promote normal healing and prevent disabling deformities. Avoiding pelvic deformity helps the patient avoid potential associated chronic pain and gait disturbances among others.

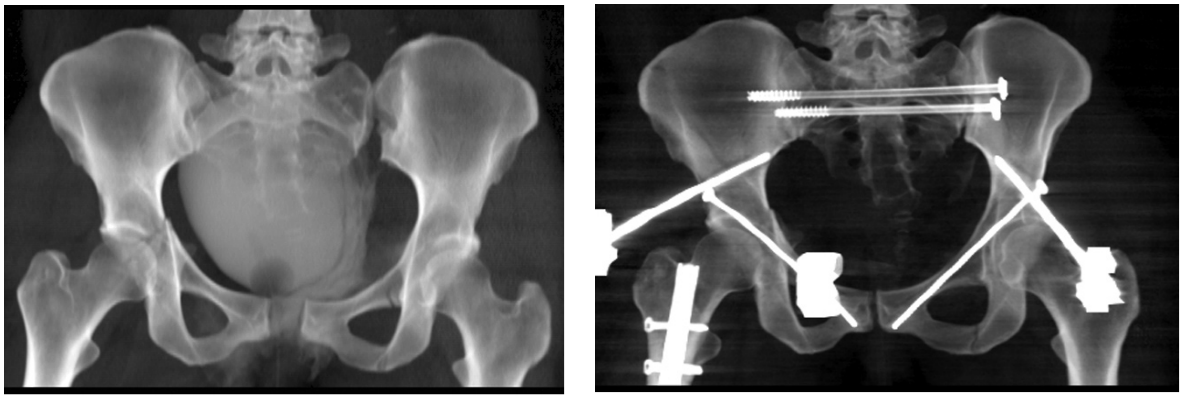
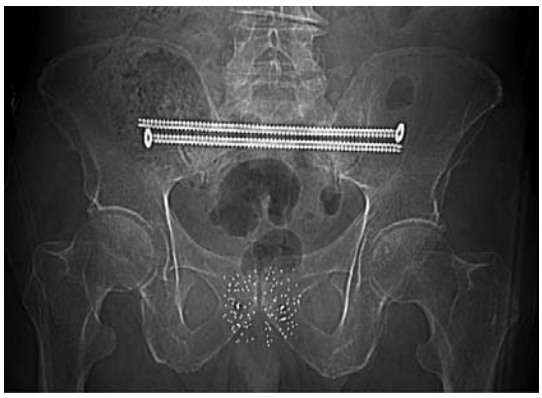


Figure 2: (A&B) A. The plain pelvic radiograph demonstrates an unstable and displaced pelvic ring disruption and extra-peritoneal bladder injury. The patient was injured in a high-speed car crash and also had a right sided femur fracture. The pelvic injuries include a symphysis pubis disruption, left mid-ramus fracture, left sacroiliac joint (SIJ) disruption, right incomplete SIJ injury, and right transverse acetabular fracture. B. After acute evaluation and resuscitation, her pelvic injuries were treated with manipulative reduction using an anterior pelvic compression device, followed by trans-iliac trans-sacral screw fixation. Antegrade bilateral superior pubic ramus screws were used to stabilize the acetabular and left ramus fractures, and the pelvic compressor was then exchanged for routine anterior pelvic external fixation. A total of six small stab wounds were used to apply the pelvic fixation. The pelvic procedures took less than 3 total hours to complete with negligible operative blood loss. Next her right femur fracture was treated with a medullary reamed locked nailing at the same anesthetic.



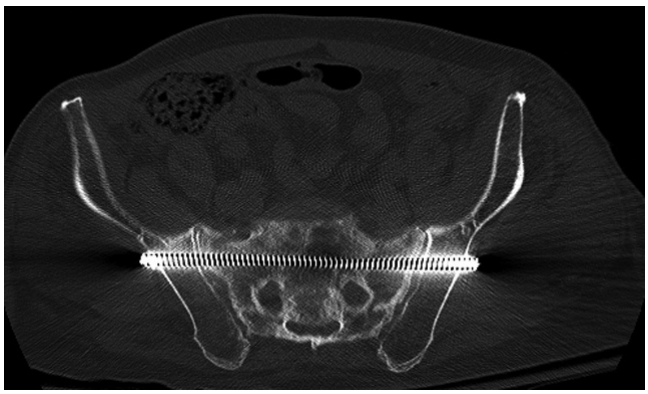


Figure 3: (A&B) A. This active 78 year old male developed severe lumbosacral pain weeks after external radiation treatment for his prostatic cancer. He was an avid tennis player but was unable to walk due to posterior pelvic and low back pain. Radiographic evaluation revealed a displaced U-shaped insufficiency fracture of the upper sacrum. He opted for percutaneous fixation of the fracture using bilateral transiliac-transsacral screws. B. The postoperative pelvic CT scan image demonstrates the fracture sites and screw locations. His pain resolved soon after surgery, and he returned to his prior activities 2 months later.

Minimally invasive pelvic surgery is obviously advantageous. While not every pelvic ring injury is amenable to it, the great majority of these injuries are. Its success depends on early intervention, complete preoperative planning, high quality fluoroscopic imaging, accurate overall pelvic reduction, thorough knowledge of the pelvic OFPs, and stable fixation.

Recommended Reading

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