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An Insight about Operative Treatment Of Sacral Fractures With Traumatic Spino-Pelvic Dissociation

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Abstract: Management of sacral fractures should be carefully planned based on careful patient evaluation. Decision making in treatment should take into consideration a number of factors. Fracture pattern and stability, neurologic status, the patient's medical condition, and associated additional injuries. Timing of treatment should also be optimized , the benefits of early treatment and mobilization in trauma patients must be weighed against the risk of operating on patients with hemodynamic instability, compromised pulmonary function, or intracranial injuries. The goals of treatment in sacral injury should include : healing of the fracture in physiologic alignment restoring pelvic stability, Stabilized the potential for recovery of neurologic deficits, and stabilize the complications associated with prolonged recumbency. Surgical intervention for patients with a sacral fracture with SPD should incorporate clear and realistically attainable goals, including: Fracture stabilization and lumbosacral realignment. Restoring of anatomic sagittal alignment of the sacrum, optimization of the chances for neurological recovery,adequate debridement of open injuries and compromised soft tissues, and minimization of additional morbidity.

Keywords: *Operative Treatment, Sacral Fractures, Traumatic Spino-Pelvic Dissociation*

Introduction

Management of sacral fractures should be carefully planned based on careful patient evaluation. Decision making in treatment should take into consideration a number of factors. Fracture pattern and stability, neurologic status, the patient's medical condition, and associated additional injuries [1].

Timing of treatment should also be optimized , the benefits of early treatment and mobilization in trauma patients must be weighed against the risk of operating on patients with hemodynamic instability, compromised pulmonary function, or intracranial injuries [2].

Early treatment in poly trauma patient may be associated with high morbidity and mortality, conversely treatment delay increases the complexity of surgery resulting in less favourable outcome [3].

The goals of treatment in sacral injury should include : healing of the fracture in physiologic alignment restoring pelvic stability, stabilization the potential for recovery of neurologic deficits, and stabilization the complications associated with prolonged recumbency [4].

Non-operative Treatment

Nonoperative treatment may be selected in some patients as the most favourable method for achieving fracture union and recovery of neurologic deficits if acceptable alignment can be achieved and long-term immobilisation is tolerated [5].

Indications for nonoperative management are vague and historically have included nearly all sacral fracture patterns. < 1 cm displacement and no neurologic deficit, nonoperative treatment is most attractive in unilateral fractures that are minimally displaced and have no associated neurologic deficits [6].

Insufficiency or stress fractures are also usually amenable to nonoperative treatment despite their frequently bilateral involvement. Along with activity modification and correction of underlying metabolic conditions, nonoperative treatment has a high likelihood of success in the majority of insufficiency and stress fractures [5].

Contraindications to nonoperative care are relative but include: fractures with soft tissue compromise, an incomplete neurological deficit with objective evidence of neural compression, extensive disruption of the posterior lumbosacral ligaments causing instability [7].

Methods : Nonoperative care consists mainly of activity modification aimed at preventing further fracture displacement. This may consist of prolonged bed rest in skeletal traction, bed rest in a brace immobilization with a thoracolumbar spinal orthosis with protected weight bearing, or early mobilization with protected weight-bearing [7].

The typical time frame for healing of a posterior pelvic ring fracture is two to four months. This allows for a transitional period of protected weight bearing for one to two months.

• Complications of Conservative treatment : Whenever treatment involves prolonged recumbency, it is necessary to address the potential dangers of thromboembolism, pulmonary complications, and skin breakdown. Progressive fracture displacement and long-term postural problems arising from sagittal imbalance, deterioration of neurological function, or persistent pain with attempts at mobilization may indicate failure of conservative treatment [8].

Operative Treatment:

• Indications : unstable fractures, neurological deficit, severe axial or sagittal spinal misalignment, , failure of conservative treatment (Persistent pain after non-operative management or Displacement of fracture after non-operative management [6].

-Surgical Decision Making:

Surgical intervention for patients with a sacral fracture with SPD should incorporate clear and realistically attainable goals, including:

Fracture stabilization and lumbosacral realignment. Restoring of anatomic sagittal alignment of the sacrum, optimization of the chances for neurological recovery, adequate debridement of open injuries and compromised soft tissues, and minimization of additional morbidity [1].

Anatomic sagittal alignment of the sacrum is, however, essential for overall spinal balance as the position of the S1 sacral endplate in relation to the femoral heads is an integral feature of pelvic incidence (PI). PI is increasingly recognized as a pivotal factor in spinal balance as it influences the individual magnitude of lumbar lordosis and thoracic kyphosis. The restoration of the sacrococcygeal angle (SCA) and PI therefore seems desirable as it potentially reduces the risk of long-term postural problems arising from sagittal [9].

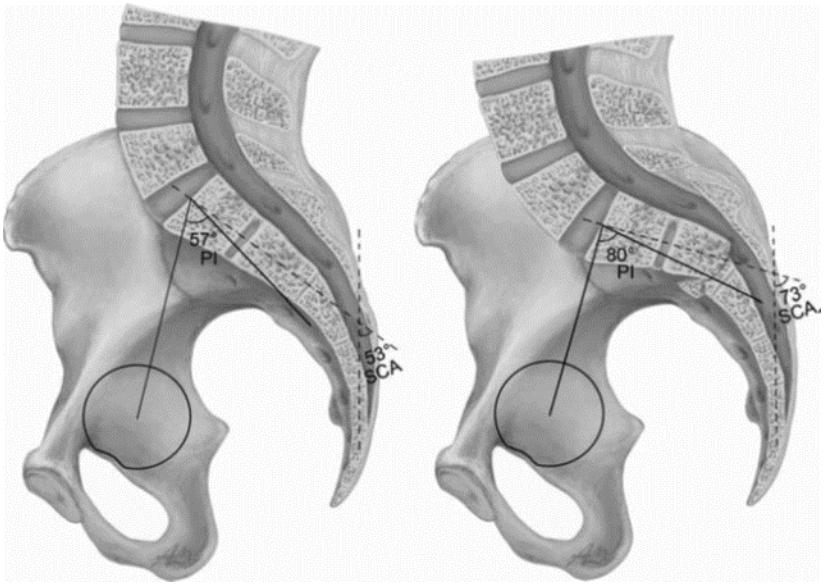


FIGURE 1. Normal pelvic incidence and sacrococcygeal angle compared with increased angles in U-shaped fractures. [9]

-Reduction Technique

Indirect Reduction :

Minimally displaced type 1 fractures usually require no formal reduction maneuver, and by positioning the patient prone, creating postural pelvic extension, any residual kyphotic deformity can be corrected [10,11]

Percutaneous indirect reduction technique in which the proximal fragment is manipulated with a pair of Schanz pins in the L5 pedicles and the distal fragment is manipulated with Schanz pins in the posterior superior iliac spines (PSIS) [12]

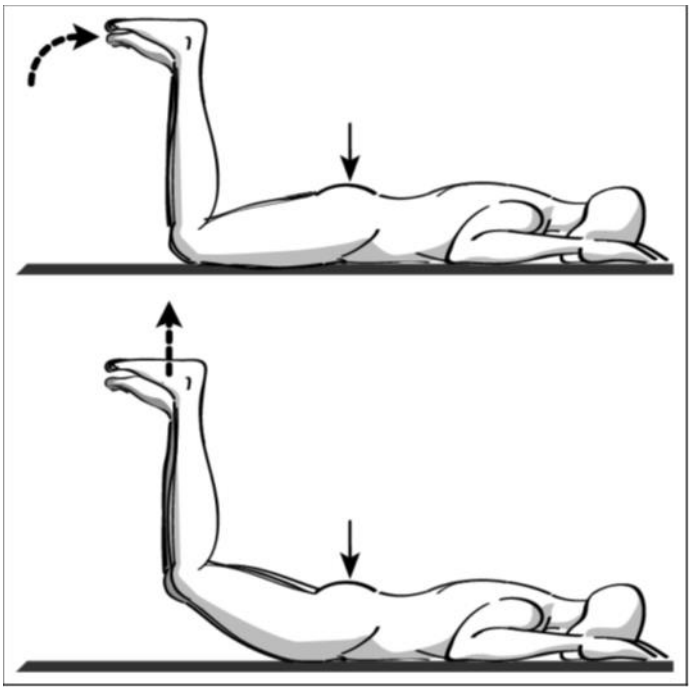


FIGURE 2 .Indirect Reduction maneuver demonstrating hyperextension of the hips with counterpressure over the posterior sacrum. [13]

Direct Open Reduction :

A more direct method of reduction, involves an open dorsal midline approach and insertion of a single Schanz pin in the upper sacral body segment between the S1 and S2 roots. This method allows for disimpaction and direct fracture reduction. Countertraction was achieved using either bifemoral skeletal traction or an AO femoral distractor with one Schanz screw in the L5 pedicle and another in the ilium [14].

-Surgical Fixation options

Surgical Fixation options range from minimally invasive techniques to open reduction and internal fixation.

Two types of Surgical Fixation: Posterior pelvic ring stabilization (PRRFx) and Spino or Lumbo pelvic fixation (SPF)

Several intraoperative reduction techniques have been described. These include open, closed, and percutaneous techniques [13].

The timing of any surgical intervention should be chosen on the basis of treatment goals, the patient's general medical status, and the invasiveness of the surgical procedure [15].

Posterior pelvic ring stabilization / Fixation (PRRFx)

Various methods of posterior pelvic ring fixation have been described, including sacral bars, tension band plating, and iliosacral screws [16].

-Iliosacral screws: Percutaneous screw fixation

Percutaneous screw fixation of posterior pelvic ring injuries has become popular with the advent of large cannulated screws and improved fluoroscopic imaging.

Technique:

All patients were operated on supine position with radiolucent table. Pelvis was slightly elevated with folded towel under ipsilateral buttock, kept at edge of table. True lateral view of pelvis, inlet, outlet and anterio-posterior views were ensured and marked on the C- arm. The position of C-arm on the floor in relation to operation table was also marked which was helpful in easy and quick access to views during surgery. True lateral view was ensured when two sciatic notches overlap with each other and end plates of S1 vertebra were also overlapped. Iliac cortical density (ICD) needed to be well defined for secure entry point for iliosacral screw fixation. True inlet view was obtained when anterior edge of S1 and S2 overlap and vertebral canal was well defined. Similarly, when superior edge of symphysis pubis overlaped S2, true outlet view was confirmed. [17]. After draping, reduction of sacral fracture was ensured. Upper tibial skeletal traction was used for longitudinal traction. If required, percutaneously applied ball spiked pelvis clamps on iliac blade was used to get reduction. Entry point for sacral screw was confirmed on lateral view. It should be below and behind ICD. A stab incision was made and 2 mm guide wire was gently tapped into iliac blade at entry point so that it didn't get dislodged during subsequent procedure. C-arm was now rotated to obtain Inlet, outlet and AP views and guide wire was advanced further in such a way that, guide wire was superior to S1 foramen in outlet view, below L5-S1 intervertebral disc space in AP view, within S1 body in inlet view. Once positioning of guide wire was ensured in all views and confirmed that it was not extraosseous or into vertebral canal, required length of screw was measured indirectly. Appropriate length 7 mm cannulated cancellous screw (CCS) was passed under C arm guidance after drilling with 4.5 mm cannulated drill. While passing two screws, simultaneous advancing both screws turn by turn was helpful when they were very near to each other. Partially threaded CCS with washer was used for sacroiliac joint disruption and fully threaded CCS for sacral fracture. Similar procedure was repeated for contra lateral side when required [18].

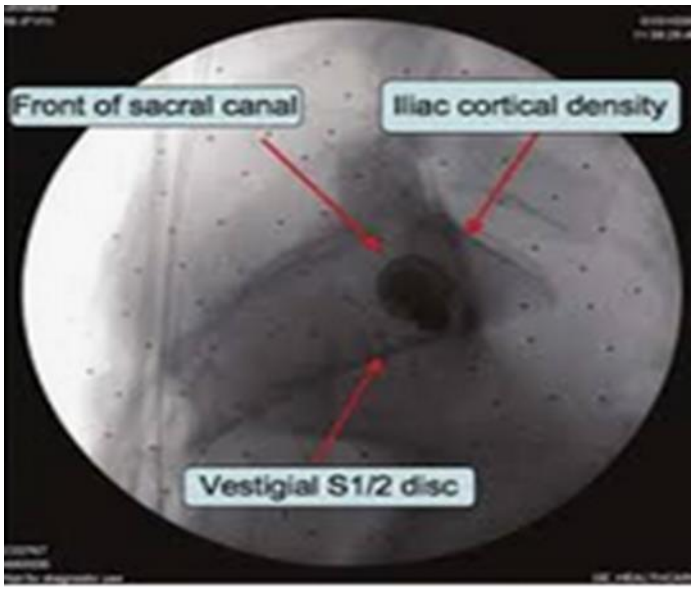
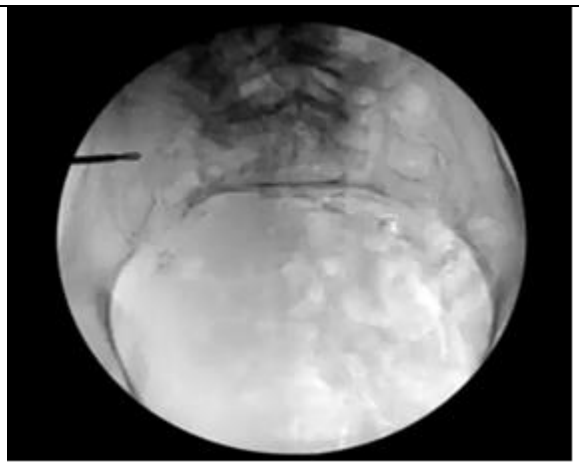
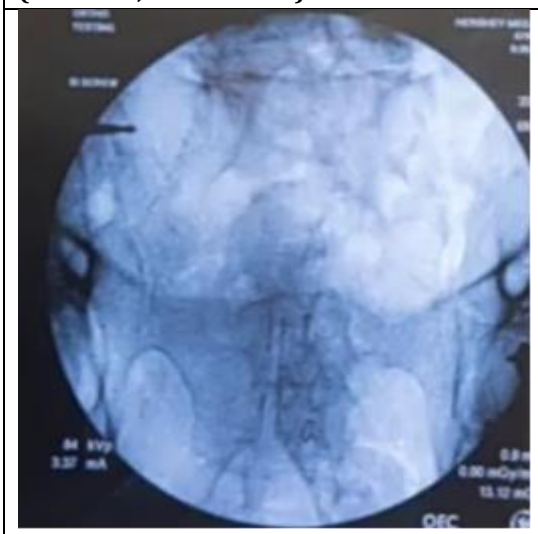


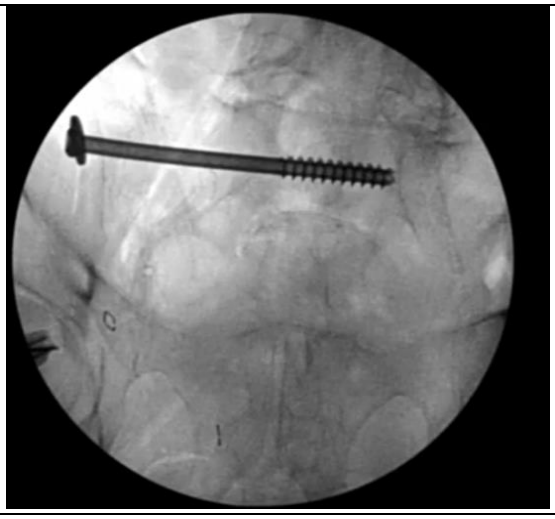
Figure.3 :Landmark for insertion of iliosacral screw on the lateral view(ICD). [18]

Stab incision
(Shrestha, D et al 2015)



Guide wire in inlet view. (Shrestha, D et al 2015)



Guide wire in outlet view(Shrestha, D et al 2015)	**Insertion of CCS screw (Shrestha, D et al 2015)**
	
Position of screw in lateral view (Shrestha, D et al 2015)	**Position of screw in inlet view (Shrestha, D et al 2015)**

Screws placed percutaneously under fluoroscopy but surgeon should avoid L5 nerve root and avoid over compression of fracture. This technique may cause iatrogenic nerve dysfunction. Screw placement posterior to the ilio cortical density (ICD) ensures safe screw placement [17].

Contraindications :

Percutaneous placement of sacroiliac screws may be contraindicated in patients with Aanomalous transitional lumbosacral anatomy or when closed fracture reduction cannot be accomplished or with presence of Comminuted S1 body (SPD roy-camille type 4)

Advantages: minimaly invasive,easy method of fixation.

Disadvantages: loss of fracture reduction and fixation in a malreduced position., Does not allow for removal of loose bone fragments, It is not used in osteoporotic bone [19].

-**Posterior tension band plates **

Indications : Transiliac tension band plate is indicated for significantly displaced sacral fractures that are not adequately stabilized by iliosacral screw alone the plate may also provide limited compression to the fracture [20]

Advantages: Allows for direct visualization of fracture. Recently, minimally invasive surgery with transiliac plate for a pelvic fracture has been reported, this technique consists of closed reduction and percutaneous posterior plate placement through two small incisions to minimize soft tissue damage. [20]

Disadvantages : May cause wound healing complications

Technique : Patient is placed in the prone position. Two vertical incisions placed lateral to the PSIS and a limited portion of the gluteus maximus is reflected off the erector spine fascia. A straight 10 or 12-hole, 4.5-mm reconstruction plate is used, the optimal position of the dorsal tension band plate is just below the PSIS. This decreases plate prominence and ensures that the screws in the ilium are anchored in the strong bone of the sciatic buttress. The plate is typically inserted from the side of the open reduction and tunnelled through to the contralateral surgical site, 1/2-inch osteotome is passed from one incision, ventral to the erector spinae fascia, The unbent straight pelvic reconstruction plate is then passed along the same track until stabilization in the second incision. A screw is inserted bilaterally between the tables of the ilium into the sciatic buttress.

Tightening these screws adds tension to the plate over the dorsum of the sacrum and causes compression of the sacral fracture [20].

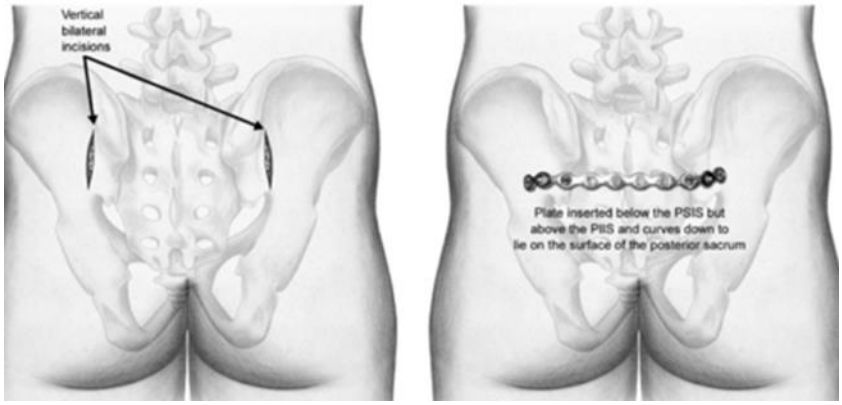


Figure.4: Posterior tension band plating for sacral fractures. [20]

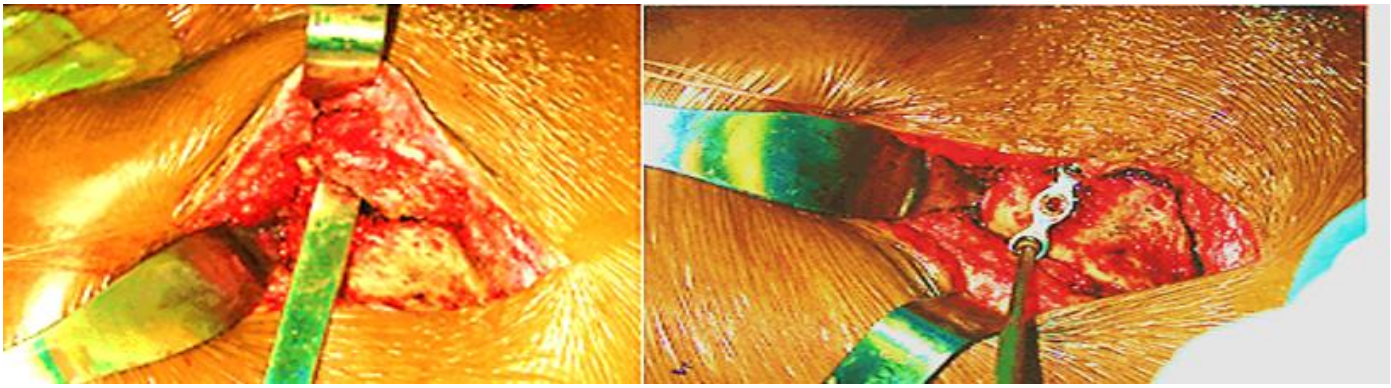


Figure 5. Surgical steps of posterior iliosacral tension band platting. [20]

-Lumbopelvic fixation (LPF)

Advantages: Lumbopelvic fixation provides the biomechanically strongest fixation of sacral fractures with SPD. Fixation is obtained rostrally by segmental pedicle screw fixation in the lumbosacral spine and caudally by long screw fixation in the ileum. The construct spans the sacrum and mimics the normal load transfer from the lumbar spine to the pelvis. The strength of the construct permits immediate weight bearing without external bracing [21].

Disadvantages : Screw malposition can be catastrophic, potentially injuring neurovascular structures in the sciatic notch or the pelvic viscera or penetrating the acetabulum. The rod breaks from fatigue failure, an expected consequence of continued sacroiliac joint motion. Late rod fracture is asymptomatic in the majority of cases and the need for routine hardware removal is questionable. Infection and wound related problems are common [22].

Technique:

Lumbopelvic fixation is performed through a dorsal approach with the patient in the prone position. The longitudinally oriented constructs are placed laterally, adjacent to the posterior iliac wings. The lateral placement also allows posterior decompression of the neural elements, as well as open reduction of the sacral fracture. Under fluoroscopy control, pedicular screws were placed through L4 pedicles, and the intact L5 pedicles. Screw placement is performed under fluoroscopic guidance to ensure correct screw orientation. A thorough understanding of pelvic anatomy and facility with fluoroscopic positioning is necessary for verification of correct screw placement. [21].

The subcutaneous tissue is dissected off of the lumbosacral fascia to the level of the posterior superior iliac spine. Often the PSIS can be palpated, and, if necessary, its position can be confirmed by intraoperative fluoroscopy or radiographs. A longitudinal or slightly oblique incision is made in the fascia over the PSIS. The incision is extended in caudad and cephalad directions on the iliac crest with respect to the PSIS. At the level of the PSIS, both the inner and the outer tables of the ilium are identified and are dissected free of soft tissues with Cobb elevators and a Bovie cautery. With a rongeur or chisel, the bone over the PSIS and slightly anterior to it is removed to accommodate the iliac screw head and prevent hardware prominence. The degree of resection depends on the bulkiness of the implant and on the connector that will subsequently connect the screw to the longitudinal rod. With a pedicle seeker or a curet, the path in the ilium toward the anterior inferior iliac spine then is developed. Fluoroscopy can be used to confirm this path. Alternatively, some surgeons may choose to expose the outer portion of the ilium to the sciatic notch and use this reference when directing the path of the screw. The typical trajectory is 25° of lateral angulation from the midline and 30° of caudad angulation from the vertical. The path of the screw is palpated with a ball-tipped probe to check for violations of the walls of ilium. The length of the screw is marked on the probe and is measured. The iliac screw should be at least 80 mm long and 7.5 mm in diameter. [22].

The iliac path then is tapped unless self-tapping screws are used. The appropriately sized screw then is inserted in the same trajectory. Intraoperative fluoroscopy can be used to check its path during placement. The screw then is seated fully to ensure that its head or connector is recessed adequately with respect to the remaining portions of the ilium anterior and posterior to the resected rim of the posterior superior iliac spine. Finally, the screw is connected to the longitudinal rod by a connector tunneled anterior to the paraspinal muscles. [23].

Direct decompression when indicated, was achieved through laminectomy from L5 down to S4 with exploration of the dura and all insulted roots including partial anterior foraminotomy when needed. Indirect decompression, when indicated, was created through reduction. [22].

Reduction was achieved gently through longitudinal traction and manipulation through bone hooks and bilateral iliac Schanz screws joy sticking; it was maintained via large reduction and/or pelvic clamps [22].

Alternatively, in some instrumentation systems, the rod can be contoured to attach to the iliac screw itself. Finally, full-length posteroanterior and lateral radiographs are made. A pelvic radiograph also should be made to ensure that there has been no violation of the acetabulum or the sciatic notch [21].

Figure.43: Lumbopelvic fixation is shown with pedicle screws in L4 and L5 and iliac screws placed into the sciatic buttress. [23]

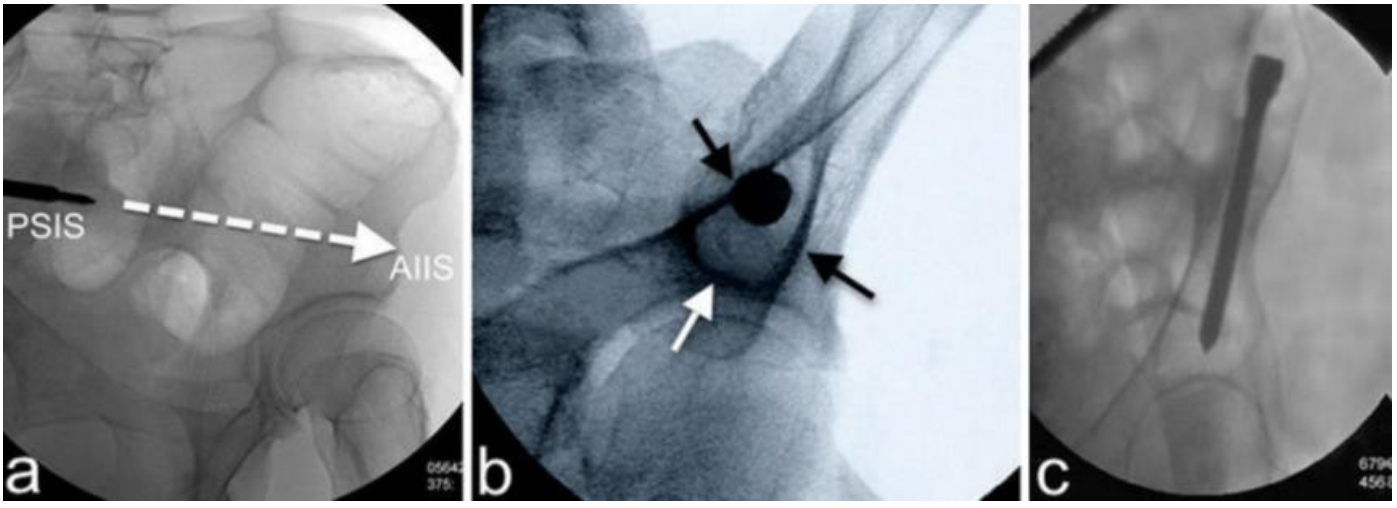


Figure. 6 An intraoperative C-arm control of iliac screw insertion. A- The initial iliac oblique view confirms the screw direction from the posterior superior iliac spine (PSIS) to the anterior inferior iliac spine (AIIS). B- The conjugated obturator-outlet view shows the contained screw within the teardrop formed by the inner and

outer iliac tables (black arrows) and bony roof of the sciatic buttress (white arrow). C-The conjugated obturator-inlet view confirms the intraosseous positioning of the iliac screw. [22].

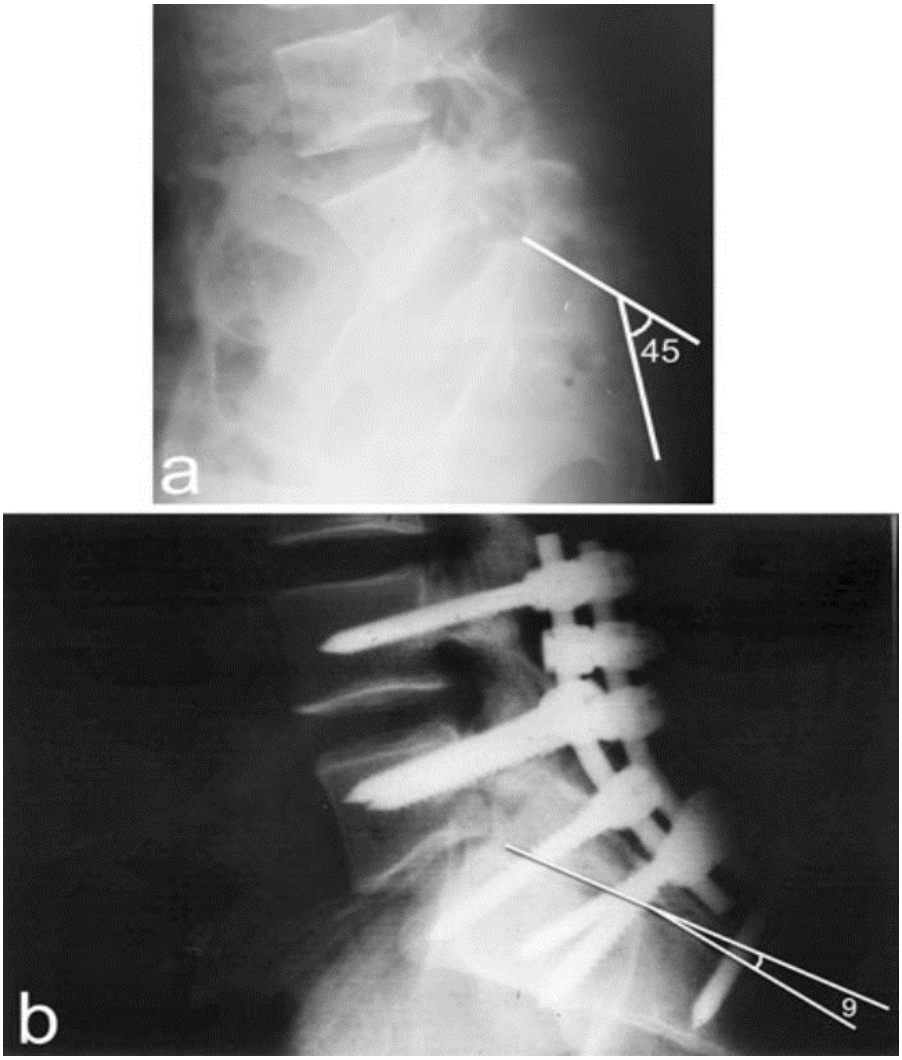


Figure. 7 A preoperative lateral radiograph shows 45 dg _ initial transverse sacral fracture kyphosis angle. B The same radiograph at final follow up with improvement of the angle down to 9 [22].

Triangular Osteosynthesis

The optimal stabilization of sacral fractures with SPD may require the use of multiple methods of fixation. Lumbopelvic fixation can be combined with iliosacral screw fixation, the so-called triangular osteosynthesis technique to obtain optimal fixation in the vertical direction along the weight bearing axis and the horizontal direction stabilization the pelvic ring. Lumbopelvic fixation may also benefit from adjunctive sacral plating, utilized solely to fine tune fracture realignment and prevent recurrent displacement and canal compromise, while the lumbopelvic fixations role is to neutralize the bulk of the loads being transferred across the sacrum [8,23]

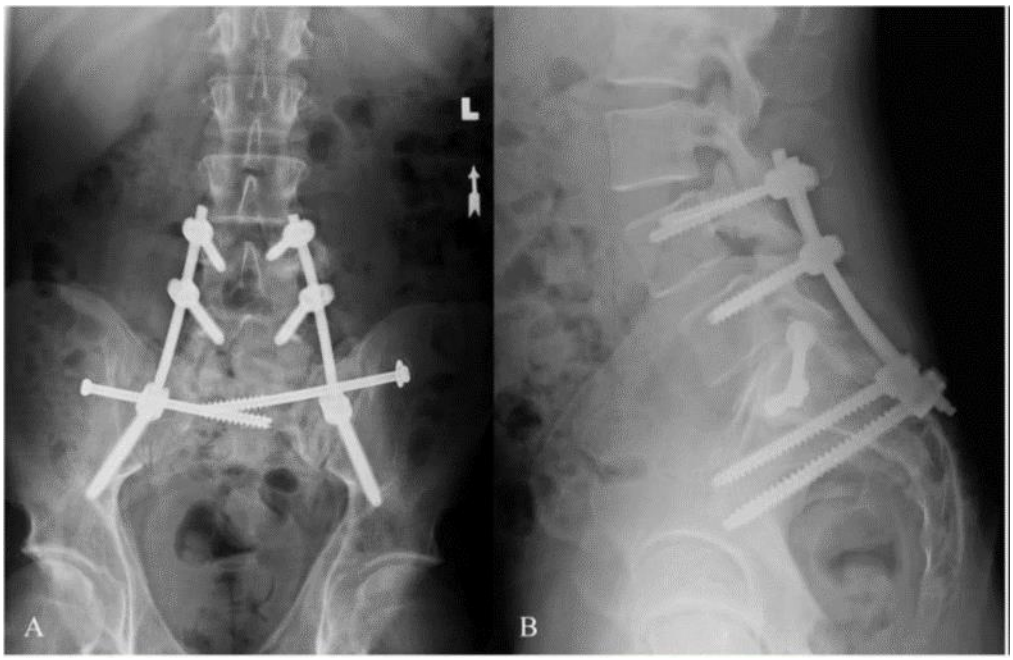


Fig. (8): Iliosacral and lumbopelvic fixation.(Triangular Fixation) [8]

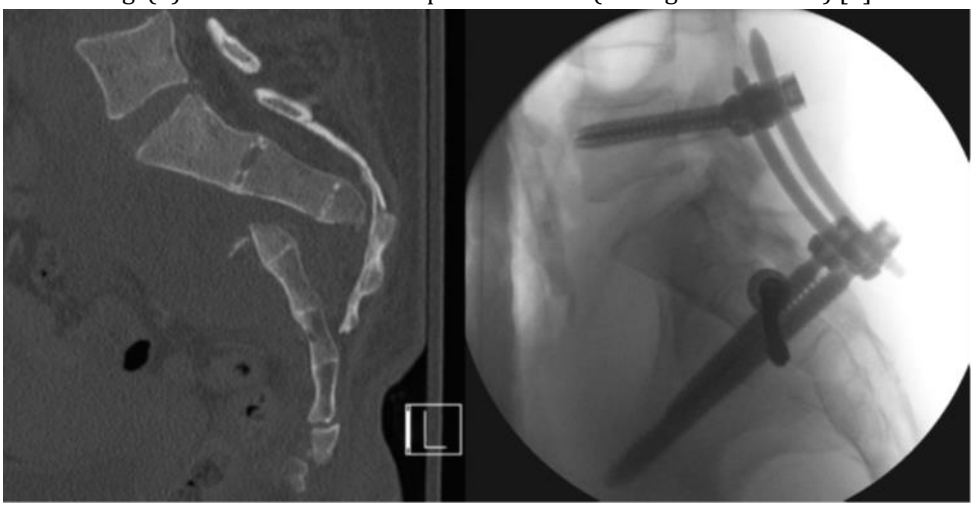


Fig. (9): Preoperative CT (left) and intraoperative fluoroscopy (right) demonstrating adequate reduction [13].

Neural Decompression:

Neural decompression can be achieved directly or indirectly. Indirect decompression can often be achieved with fracture reduction, which is best accomplished early before consolidation of fracture hematoma. [22].

If neural impingement persists and is associated with a neurologic deficit, direct decompression should be considered. [23].

In patients with sacral root deficits, direct decompression alone by laminectomy has been advocated to enhance the possibility of neurologic recovery while minimizing the potential for complications associated with a more extensive surgical stabilization procedure. [22].

Surgical exposure for decompression is generally through a straight posterior midline approach Decompression can be performed focally for selective forminal impingement or full laminectomy to achieve a more comprehensive decompression of the S1 to S4 neural elements. [22].

In the case of L5 root entrapment between the L5 transverse process and an alar bone fragment, decompression is performed by following the root laterally onto the shoulder of the ala and removing the offending fragment [24].

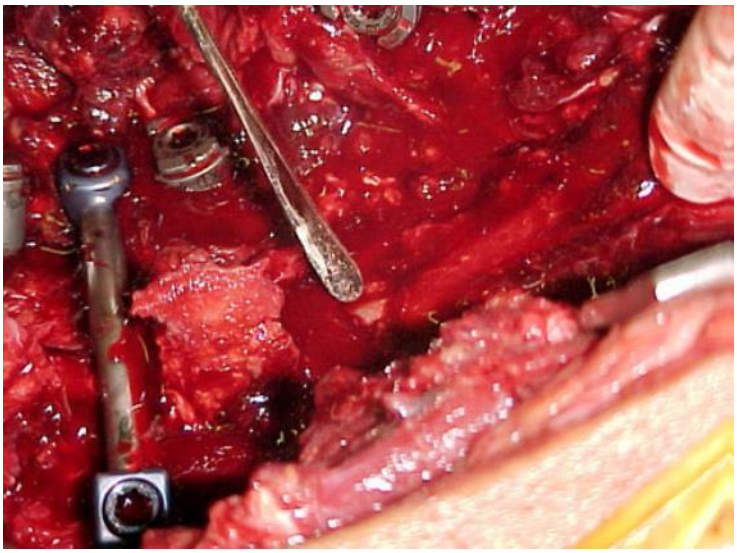


Fig. 10 An intraoperative photo shows direct decompression of complete cauda equina syndrome through bilateral laminectomy from lumber five down to sacral four vertebrae [22]**.**

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