# Sacral fractures

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Traumatic sacral fractures are rare, but they constitute a major cause of death and disability in high-energy blunt trauma patients. Almost every trauma patient who suffered a sacral fracture has additional injuries (1,2). If the patient is hemodynamically unstable the primary resuscitation is carried out according to the ABCDE principles (3). Once patients are stabilized, careful assessment and definitive treatment of the unstable pelvic ring injuries can be done. Various options for management for different types of unstable sacral fractures have been proposed.

## *Classification*

According to AO/ASIF classification system the pelvic ring fractures are graded into three types, A, B, and C, in order of increasing severity (4). Type A injuries are stable including avulsion fractures, fractures of the iliac wing and transverse fractures of the sacrum. Type B injuries are rotationally unstable but vertically and posteriorly stable. They may be caused by external rotatory forces (open book injuries) or internal rotatory forces (lateral compression injuries). Type C unstable injuries are complete disruptions of the posterior sacroiliac complex, involving vertical shear forces. Posterior pelvic ring injuries form the basis of the subgroups; fractures of the ilium type C1-1, sacroiliac dislocation and fracture dislocation type C1-2, and sacral fractures type C1-3. The posterior injury may be bilateral. The bilateral posterior lesion may be vertically stable on one side and unstable on the other (type C2), or unstable on both sides (type C3).

Sacral fracture patterns are commonly categorized using the Denis classification system (5). It divides sacral fractures into three zones: alar (zone 1), foraminal (zone 2) and central (zone 3). Denis, Davis and Comfort (5) found that injury to nerves occurred in 5.9% of fractures lateral to sacral foramina. In transforaminal fractures 28.4% of patients had a neurological deficit. Central fractures had the highest prevalence (56.7%) of nerve injury.

Denis's system does not recognize the combination of the bilateral vertical and transverse fracture lines that induce spinopelvic dissociation. This injury results in dissociation of the spine and upper central segment of the sacrum from the pelvic ring and caudal sacral segments. Roy-Camille et al. (6) described this injury but classified only the transverse sacral fracture, not the bilateral vertical fracture components. Roy-Camille et al. divided transverse sacral fractures into three types, and later on Strange-Vongsen and Lebech (7) added a fourth type (Figure 1). In this classification, type 1 is a flexion injury without translational displacement; type 2 is a flexion injury with anterior translational displacement; type 3 is an extension injury with posterior translational displacement; and type 4 is axial loading injury with segmentally comminuted S1 body (8).

## *Radiographic examination*

Anteroposterior pelvis radiograph and CT show the vertical sacral fracture lines. However, the diagnosis of traumatic spinopelvic dissociations is often missed or delayed because of the difficulty in imaging the upper

sacrum and the frequency of concomitant severe injuries. Angulation of the fractured segment can produce a paradoxical inlet view of the upper sacrum on the standard anteroposterior pelvic radiograph (9). Delayed diagnosis is avoided by high clinical suspicion, early lateral sacral radiographs, and pelvic CT sagittal reconstructions.

## *Neurologic injury*

AO type C1-3 fractures of the sacrum may result in a neurologic injury in up to 41 % of cases (10) and sacral fracture-dislocations with spinopelvic dissociation in up to 100 % of cases (8,11). The nerve injury may involve more than one nerve root, and be unilateral or bilateral depending on the fracture pattern and location. The injury can range from a neuropraxic injury due to nerve contusion or shearing injury, to transection of nerve roots.

Clinical examination of trauma patients sustaining sacral fractures requires both examination of lower extremity sensory and motor function, and examination to identify injuries to the lower sacral plexus. A rectal examination is performed to evaluate sphincter contraction and to exclude possible rectal injury as a sign of an open pelvic fracture. Light touch and pinprick sensation should be assessed for the perianal dermatomes of S2 to S5.

## *Vertically unstable sacral fractures*

An external fixator applied anteriorly cannot restore enough stability to an unstable type C disruption of the pelvic ring to allow mobilization of the patient without risking redisplacement of the fracture (4,10,12,13). Therefore open or closed reduction and internal fixation has become the method of choice for stabilization of type C pelvic ring injuries with sacral fractures.

Biomechanical studies have shown that the best stability in type C pelvic ring injuries can be achieved by internal fixation of the posterior and anterior pelvic ring injuries (4,14). Therefore fixation of any associated anterior pelvic ring injury is essential to improve the fixation stability of the whole pelvic ring (15,16).

## *Fixation techniques*

Sacral fractures are the most difficult to reduce and stabilise. Biomechanical studies have demonstrated differences in stiffness of fixation constructs in sacral fractures (17–19). Following anatomic reduction, there are several different types of fixation techniques for vertically unstable sacral fractures including iliosacral screws, transiliac bars, transiliac plates, local small plates, and spinal instruments.

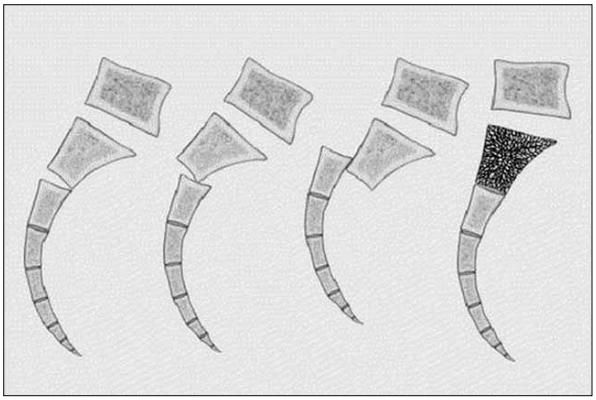

*Figure 1. Subclassification of Denis zone 3 fractures according to sagittal plane alignment by Roy-Camille et al, and Strange-Vognsen and Lebech: type 1, flexion injury without translational displacement; type 2, flexion injury with translational displacement; type 3, extension injury; and type 4 (Strange-Vognsen), axial loading injury with segmentally comminuted S1 body.*

### Iliosacral screw fixation.

The gold standard for fixation of vertically unstable sacral fractures. Severely displaced sacral fractures are usually approached posteriorly with the patient in the prone position through a vertical incision medial to the posterior superior iliac spine without releasing the gluteal muscles from the outer side of the iliac crest. The sacral fracture is observed and reduced with forceps. Once the reduction is obtained, the sacral fracture is fixed with two percutaneously placed 7.0-7.3 mm cannulated cancellous screws (separate small lateral skin incision) from the outer aspect of the ilium through the SI-joint into the body of S1 under fluoroscopic guidance (Figure 2). Minimally displaced sacral fractures are suitable for closed reduction and percutaneous IS-screw fixation (Figure 3). The screws should be placed at least past the midline of the sacrum.

### Ilio-iliacal techniques.

There are four main options: extraosseous transiliac/sacral bars, intraosseous sacral bars, ilio-iliacal plate osteosynthesis (20,21), and transiliac internal fixator (22).

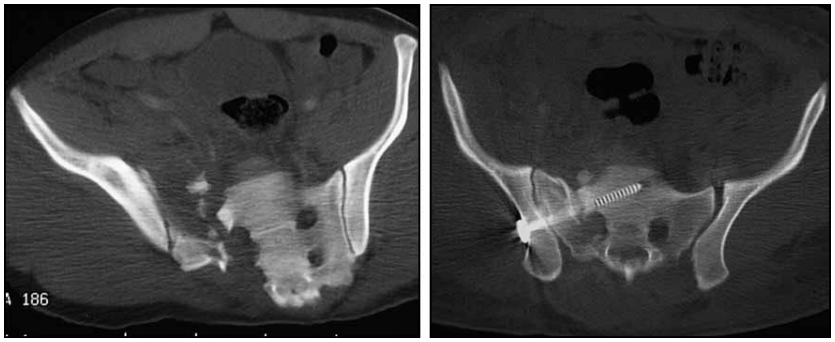


*Figure 2. Severely displaced sacral fractures need open reduction before iliosacral screw fixation (a-b).*


*Figure 3. Minimally displaced sacral fractures are suitable for closed reduction and percutaneous IS-screw fixation (a-b).*

### Direct plate fixation.

Sacral fractures have been fixed also by small local posterior plates (23). They seems to work in transalar sacral fractures lateral to the foramina of the sacrum, but the complication rate has been high (20%).

### Combined techniques.

In patients with a comminuted sacral fracture a threaded compression transiliac rod might be used to anchor the injured hemipelvis to the contralateral ilium to help supplement iliosacral screw fixation (Töölö hospital experience).

## *Sacral fracture-dislocations with spinopelvic dissociation*

Bilateral vertical sacral fractures associated with transverse fracture might form so-called H-, U-, or Y-shaped fracture patterns. Commonly, the fractures are angled and undergo translational displacement, or even complete dislocation, which result in gross spinopelvic instability and cauda equina neurologic deficits. Another common presentation is injury to the L5 and S1 nerve roots. The L5 nerve root can be injured as a result of vertical shear displacement of the sacrum and is often accompanied by a fracture of the transverse process of L5. The goals of treatment are realignment, restoration of spinopelvic stability, and decompression directly or indirectly. Fixation is achieved by connecting the lumbar spine to the ilium with segmental spinal fixation system

## *Our lumbopelvic fixation technique*

Injuries of the anterior part of the pelvic ring (whenever present) are most commonly operated on first. The method for lumbopelvic fixation includes two pairs of lumbar pedicle screws, and two pairs of iliac screws. Longitudinal rods are connected to the L4 and L5 pedicle screws after having been contoured to lie close to posterior lamina of the sacrum and medial to the posterior superior iliac spines. One or two transverse connecting rods between longitudinal rods are used to secure the fixation. Operative reduction, correction of antero-posterior and vertical displacement, and rotational deformity of both hemipelvis and the caudal segment of the sacrum, is carried out by using bilateral AO-reduction clamps placed at both caudal ends of the longitudinal rods and superior aspect of the iliac wings. To achieve this goal, simultaneous bilateral femoral manual traction and hyperextension of both hip joints might help. The lumbar spine and central upper sacral segment is then fixed to the pelvic ring by placing 8-mm screws into iliac bones and connecting

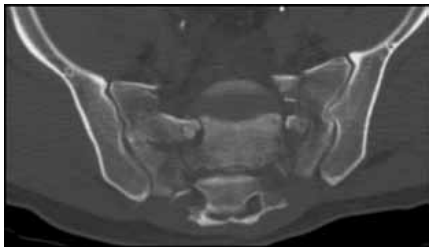

Figure 4a

Figure 4b

Figure 4c

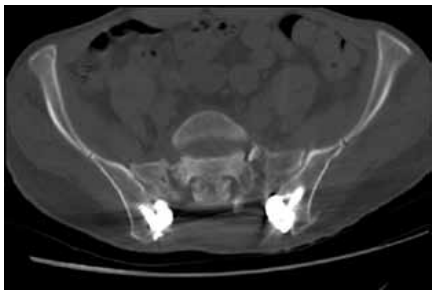

Figure 4d

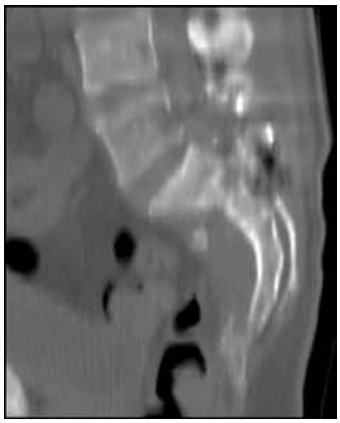

Figure 4e

*Figure 4. 37 years old male fell from the fourth floor sustaining H-shaped sacral fracture-dislocation with spinopelvic instability, cauda equina injury and bilateral L5-S1 nerve roots injuries (a-b). Operative reduction, segmental lumbopelvic fixation and sacral decompression was carried out once the patient was stabilized hemodynamically. The end radiological and functional results were good.*

them to longitudinal rods (Figure 4). Posterolateral arthrodesis across the instrumented lumbosacral levels is not normally carried out, because the internal fixator is planned to be removed later on.

## *Outcomes*

In a systematic review of treatment modalities and outcomes of pelvic ring disruptions, Papakostidis et al. (16) concluded that fixation of all the injured elements of the pelvic ring yield better anatomical results compared to more non-operative therapeutic strategies. From the functional point of view walking capacity was proved to be significantly better in the groups of operative treatment compared to non-operative group.

Poor outcomes correlate with the injury pattern of the posterior part of the pelvic ring. Sacral fractures and sacroiliac dislocations result in higher rates of back pain than posterior iliac fracture types (10). The presence of lumbosacral plexus injury correlates to unsatisfactory functional results. Functional results are also affected by poor reduction results and loss of alignment (10,16,24).

Sacral fracture-dislocations with spinopelvic dissociation can be treated with lumbopelvic fixation with a low rate of complications (8,11,25). Neurologic improvement can be expected, but the indications for surgical decompression and timing remain unclear (8).

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