Neurosurg Focus 37 (1):E12, 2014

Sacral fractures

*Mohamad Bydon, M.D.,[1] Vance Fredrickson, M.D.,[2]
Rafael De la Garza-Ramos, M.D.,[1] Yiping Li, M.D.,[2] Ronald A. Lehman Jr., M.D.,[3]
Gregory R. Trost, M.D.,[2] and Ziya L. Gokaslan, M.D.[1]

[1]*Department of Neurosurgery, Johns Hopkins University School of Medicine, Baltimore, Maryland;* [2]*Department of Neurological Surgery, University of Wisconsin School of Medicine, Madison, Wisconsin; and* [3]*Department of Orthopaedic Surgery, Washington University School of Medicine, St. Louis, Missouri*

Sacral fractures are uncommon lesions and most often the result of high-energy trauma. Depending on the fracture location, neurological injury may be present in over 50% of cases. In this article, the authors conducted a comprehensive literature review on the epidemiology of sacral fractures, relevant anatomy of the sacral and pelvic region, common sacral injuries and fractures, classification systems of sacral fractures, and current management strategies. Due to the complex nature of these injuries, surgical management remains a challenge for the attending surgeon. Few large-scale studies have addressed postoperative complications or long-term results, but current evidence suggests that although fusion rates are high, long-term morbidity, such as residual pain and neurological deficits, persists for many patients.
(http://thejns.org/doi/abs/10.3171/2014.5.FOCUS1474)

Key Words • **sacral fracture** • **instrumentation** • **review** • **outcomes**

Sacral fractures are uncommon lesions that often are under- or undiagnosed, leading to inadequate treatment and possible neurological damage. An accurate understanding of sacral anatomy, its injury mechanisms and types, as well as treatment options is pivotal to preventing neurological sequelae, such as lower-extremity weakness and urinary, rectal, or sexual dysfunction. The purpose of this article is to clinically summarize important sacral anatomy, its injury classifications, and the treatments of those injuries.

Incidence and Epidemiology

Sacral fractures may present in young adults after high-energy trauma or in elderly and osteoporotic patients after lower-energy falls. The most common mechanisms of injury leading to sacral fractures include motor vehicle accidents and falls from an elevation.[17] Sacral fractures are frequently underdiagnosed and mistreated because they commonly present in patients who are neurologically intact. In a retrospective review, Denis et al. found only 51% of neurologically intact patients with sacral fractures had the fractures detected during the initial hospitalization.[5] Close to 75% of patients who present to the hospital with sacral fractures are neurologically intact; thus, the diagnosis is often missed on the initial visit, and patients do not receive optimal treatment.[5,9] These patients may go on to develop neurological deficits due to inadequate treatment.

* Drs. Bydon and Fredrickson contributed equally to this work.

Anatomy of the Sacrum and Pelvis

Function of the Sacrum and Pelvis

Biomechanically, the sacrum's function is to transfer loads from the spinal column to the pelvis, providing both strength and stability to the pelvis and lower extremities. The pelvis functions to transfer loads from the sacrum (via the sacroiliac joints) to the hip joints.[2] Below the level of the second sacral vertebra, the sacrum is not considered essential for spinal column support or ambulation.

Bony Sacral and Pelvic Anatomy

The sacrum consists of 5 vertebrae, which typically fuse in adulthood (Fig. 1A–D). The 4 articulating points of the sacrum are as follows: the S-1 vertebra with the L-5 vertebra via an intervertebral disc and bilateral facet joints, the ala (wing) with the ilium at the sacroiliac joint, and the S-5 vertebra with the coccyx via an intervertebral disc at the sacrococcygeal joint. The sacral canal runs posteriorly to the sacral vertebral bodies and typically terminates while opening posteriorly at the level of the S-4 vertebra. The sacrum typically has 4 pairs of anterior and posterior foramina allowing passage of the sacral nerve roots.

The 2 pelvic bones (also called innominate bone or os coxa) are each composed of 3 fused bones: the ilium, ischium, and pubis; these bones are connected in the region of the acetabulum. The pubic bones articulate anteriorly at the pubic symphysis.

Ligamentous Structures

Several ligaments provide structural support to the

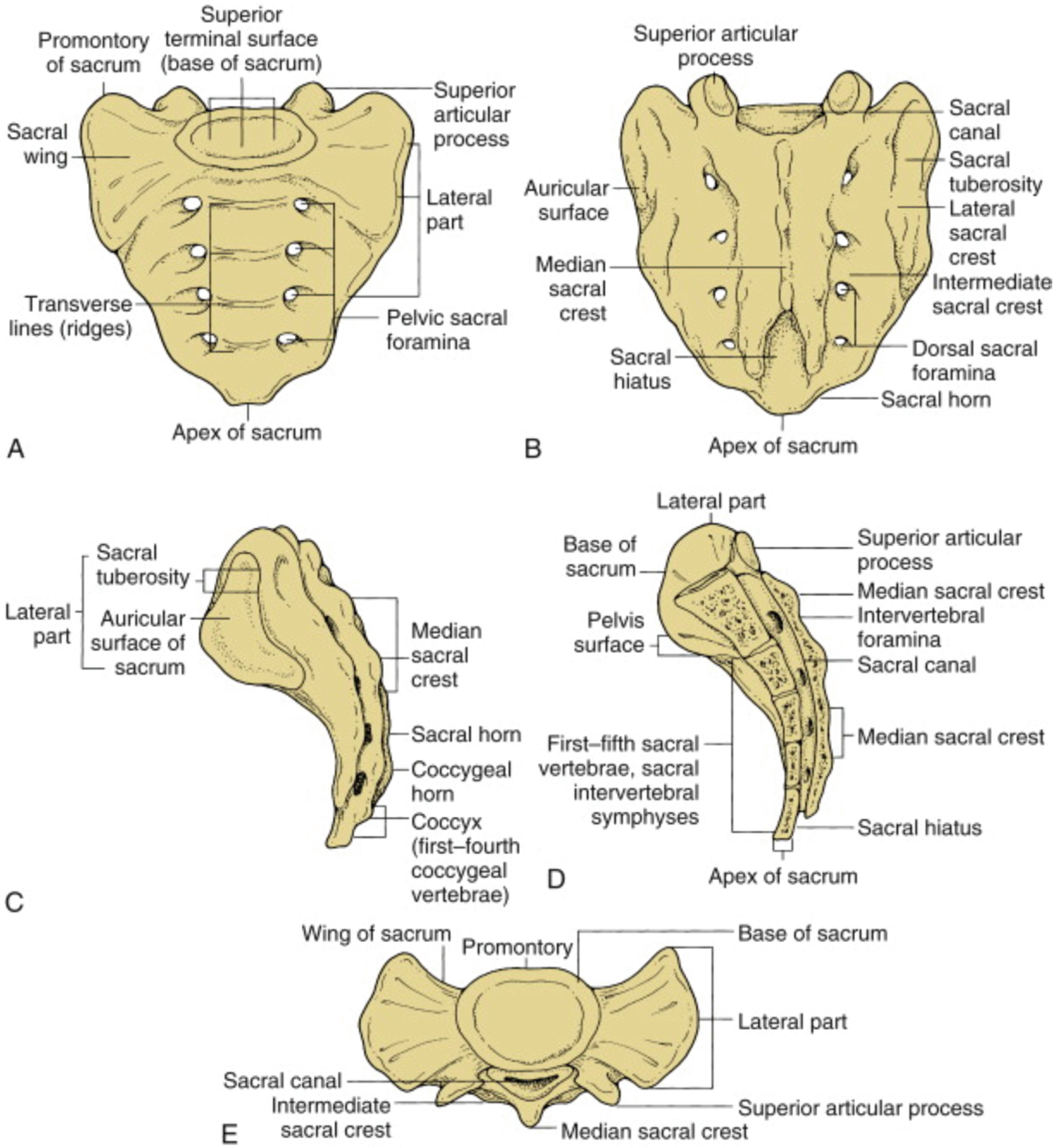

Fig. 1. Anatomy of the sacrum in anterior **(A)**, posterior **(B)**, lateral **(C)**, sagittal **(D)**, and superior **(E)** views. Reproduced with permission from Isaacs RE, Fessler RG: Lumbar and sacral spine, in *Spine Surgery* (3rd ed), Benzel et al. (eds), p 357. Copyright 2012 by Saunders, an imprint of Elsevier Inc.

sacrum and surrounding tissues. The anterior longitudinal ligament courses anteriorly over the sacral promontory. The posterior longitudinal ligament passes posteriorly over the vertebral bodies and anteriorly along the anterior surface of the sacral canal. Each sacroiliac joint receives stabilization through 3 main ligaments. The anterior sacroiliac ligament courses anteriorly and inferiorly over the joint. The interosseous sacroiliac ligament is located posterosuperior to the joint and is the largest ligament of the three. The posterior sacroiliac ligament runs posteriorly over the interosseous sacroiliac ligament. Additional ligaments that provide regional stability include the lum-

bosacral and iliolumbar ligaments, which attach at the transverse process of the fifth lumbar vertebrae. The lumbosacral ligament courses over the anterior surface of the sacroiliac joint, and the iliolumbar ligament courses over the iliac crest.

The sacrospinous and the sacrotuberous ligaments stabilize the sacrum on the pelvic bones. The sacrospinous ligaments attach to the sacrum and coccyx medially and to the ischial spine laterally. The sacrotuberous ligaments attach at the posterolateral surfaces of the sacrum and coccyx medially and the posterior superior iliac spine of the pelvic bones laterally.

The axial force from the spinal column has a force vector directed anterior to the sacroiliac joint. This force vector places an anteriorly directed rotational force on the sacrum, which is centered at S-2. The sacrospinous and sacrotuberous ligaments attached at the inferior portion of the sacrum resist excessive sacral rotation.[2]

The Sacral Canal and Nerve Roots

The sacral canal contains several structures. The sacral and coccygeal nerve roots traverse it, with the sacral dorsal root ganglia located medially and superiorly in relation to their corresponding foramina. The thecal sac tapers as it courses through the sacral canal and terminates at the inferior aspect of the S-2 vertebra. The filum terminale internum terminates along with the thecal sac, where it is invested by the thecal sac forming the filum terminale externum, at its attachment to the superior aspect of the first coccyx vertebra.

The sacral plexus is formed on the posterolateral wall of the pelvic cavity (Fig. 2). This plexus is formed from the anterior rami of S1–4 and also by contributions from the lumbosacral trunk (from the anterior rami of the L-4 and L-5 nerve roots). The following nerves arise from this plexus: superior and inferior gluteal, sciatic, posterior femoral cutaneous, pudendal, and pelvic splanchnic nerves. The superior hypogastric plexus is located between the bifurcation of the aorta and the sacral promontory, anterior to the lumbar vertebrae, and gives rise to 2 hypogastric nerves. The hypogastric nerves and pelvic splanchnic nerves (carrying parasympathetic fibers from S2–4) combine, forming the inferior hypogastric plexuses, which give rise to several additional plexuses providing innervation to the pelvic viscera (including the rectum, bladder, and reproductive organs). Each sympathetic trunk courses over the anterior sacrum.

Regional Arteries and Other Structures

The common iliac arteries bifurcate at the lumbosacral junction giving rise to the internal and external iliac arteries, which course anterolateral to the iliac veins (Fig. 3). The internal iliac arteries course in close proximity to the ala, but they do not come into contact with the bone. The external iliac arteries are separated from the sacrum by the psoas muscles.

The sigmoid colon runs close to the anterior sacrum and becomes the rectum at the level of the third sacral vertebra. These structures may be damaged along with sacral injuries.

Sacral Injuries

Facet Fractures and Dislocations

Facet injuries in the lumbosacral spine are uncommon, representing about 10% of all facet injuries in the spine.[15] These injuries occur via a flexion-distraction mechanism, leading to complete disruption of the posterior ligaments and intervertebral disc. The osseous portion of the facets may remain intact, but they are completely dislocated. The posterior walls of the lumbosacral vertebral bodies remain intact, and neural compression results from translation of one vertebral ring over an adjacent one. This type of injury differs from proper facet fractures, where the osseous elements are compromised and may be accompanied by laminae, pars interarticularis, or vertebral body fractures.

Vertebral body translation in the lumbosacral region may lead to partial or complete cauda equina syndrome, and is the result of damage to the posterior longitudinal ligament, annulus fibrosus, and intervertebral disc.[4]

Early Classification Systems

Sacral fractures were first mentioned in the literature in 1847.[23] Since that time better imaging and a higher index of suspicion have resulted in several classification systems. In 1939, Medelman classified sacral fractures into 3 main types: longitudinal, oblique, and horizontal.[16] In his study, he found that sacral fractures occurred 44% of the time when there were other pelvic fractures, which was a much higher incidence than reported in previous studies. Soon after, in 1945, Bonnin created a classification system based on the mechanism of injury, after first describing 3 mechanisms through which sacral fractures occurred.[3] The 2 groups were direct injury and indirect injury, each with subgroups further describing the fracture. In 1977, Fountain et al. published a series of 6 cases of transverse sacral fractures and classified sacral fractures as either transverse or longitudinal.[6]

The Schmidek Classification

In 1984, Schmidek et al. classified sacral fractures based on their mechanism of injury.[23] The 2 main groups were direct trauma and indirect trauma. Direct trauma was divided into 2 sections, penetrating and low transverse. Gunshot injury was found to be the most common cause of penetrating trauma, typically causing a fracture confined to the posterior pelvic ring. These fractures were often structurally stable. Low transverse fractures (defined as occurring at the level of S-3 and below) often resulted after a fall onto the buttocks. In some instances these fractures were found to cause rectal perforation and cerebrospinal fluid leaks. These fractures were typically stable, because the sacrum at this level and lower is not involved in transfer loads from the spinal column to the pelvis.

Sacral fractures due to indirect trauma resulted from forces coming from the lumbar spine or pelvis; these fractures were divided into 2 subgroups. The first subgroup of fractures included 2 types of fractures described as transverse fractures. The high transverse fracture was classically found to result from a flexion injury and of-

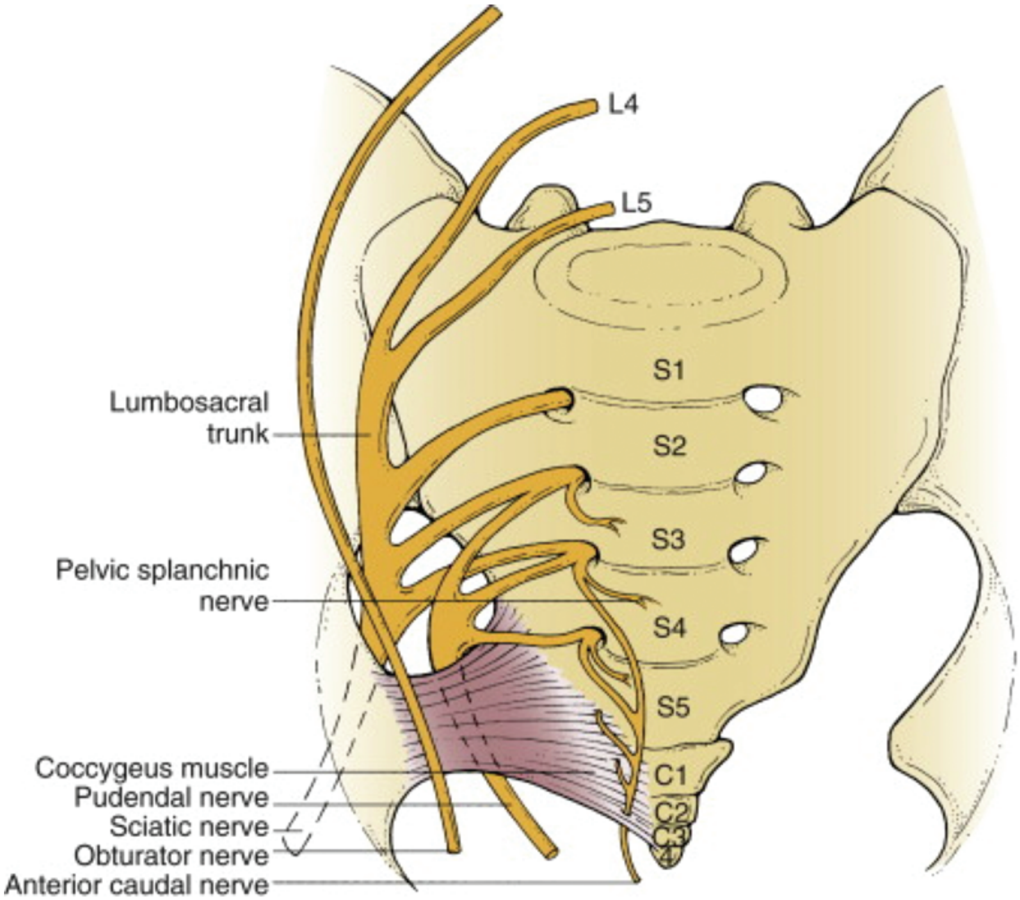

Fig. 2. The sacral plexus. Reproduced with permission from Isaacs RE, Fessler RG: Lumbar and sacral spine, in *Spine Surgery* (3rd ed), Benzel et al. (eds), p 363. Copyright 2012 by Saunders, an imprint of Elsevier Inc.

ten resulted in S-1 on S-2 spondylolisthesis. Lumbosacral fracture dislocation resulted from a similar mechanism, and was defined as a traumatic spondylolisthesis of L-5 on S-1; in this type of fracture, S-1 facet fractures were commonly seen. Transverse fractures comprised 5% to 10% of all sacral fractures studied and were often not associated with pelvic fractures. The next subgroup of fractures included 4 types of vertical sacral fractures, and these were always associated with pelvic fractures. The first type was the lateral mass fracture, which usually started at the level of the sacral notch and extended inferiorly through the first 3 anterior foramina, with the fracture fragment nondisplaced. The juxta-articular fracture type was similar to the lateral mass fracture type, but the fracture fragment was displaced. The cleaving fracture type began at the sacral notch and exited near the coccyx. The last in this subgroup was the avulsion fracture type, which occurred at the insertion sites of the sacrotuberous and sacrospinous ligaments. The combination fracture was a combination of the different types of fractures.

The authors described sacral fractures as being associated with concomitant pelvic fractures in 90% of cases. They found neurological deficits in approximately 25% of cases.

Sabiston and Wing's Classification

In 1986, Sabiston and Wing classified sacral fractures into 3 categories based on a retrospective study of 35 patients with sacral fractures.[22] These categories were as follows: 1) sacral fracture with coexisting pelvic fracture; 2) sacral fracture only in the lower segments; and 3) sacral fracture occurring only in the upper segments. The authors found that the first type of fracture was observed most frequently and the third type least frequently (incidence: first type 54.3%, second type 31.4%, and third type 14.3%). They found that neurological injury was least frequent with the second type and most frequent with the third type (incidence: first type 15.8%, second type 9.1%, and third type 100%).

The Denis Classification

This Denis classification system and its modifications are well accepted and one of the most recognized worldwide.[2] In 1988, Denis et al. created a classification system for sacral fractures based on the direction, location, and level of the fracture.[5] It was developed through sacral anatomical dissections on 39 cadavers and a retrospective study in which a series of 236 consecutive cases of sacral fractures were assessed.

Three zones are described in the Denis classification system (Fig. 4).[5] Zone I fractures are located in the region of the ala, sparing the foramina and central sacral canal. Zone II fractures are located in the region of the sacral

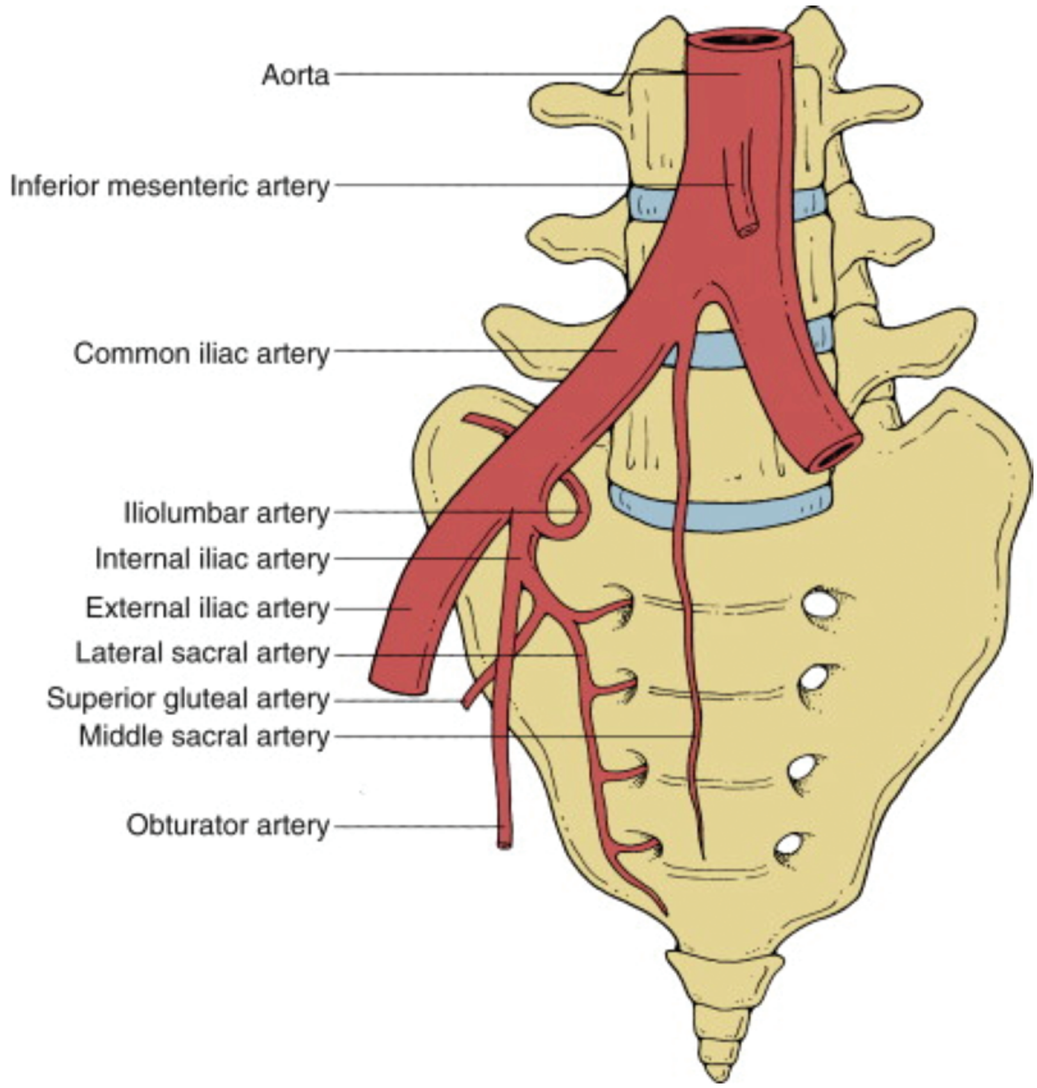

Fig. 3. Vascular supply of the sacrum. Reproduced with permission from Isaacs RE, Fessler RG: Lumbar and sacral spine, in *Spine Surgery* (3rd ed), Benzel et al. (eds), p 364. Copyright 2012 by Saunders, an imprint of Elsevier Inc.

foramina, they may also involve the ala, but they may not affect the central sacral canal. Zone III fractures are located in the region of the central sacral canal and may also involve the foramina and/or ala.

Two subtypes of Zone I (alar zone) fractures are described. Minimally displaced alar fractures were typically seen along with compression injuries and open-book type pelvic fractures. The mechanism of this lateral compression injury was described as resulting from forces causing lateral compression to the pelvis, translating to anterior compression and posterior distraction forces on the ala of the sacrum. Severely displaced fractures were seen in association with vertical shear injuries, often resulting in superior displacement of the fractured alar segment. Fractures in this zone were often not associated with neurological injury; if neurological injury was present (5.9% in this study) it typically was L-5 lumbar root damage. Additionally, avulsions of the sacrotuberous ligament were typically seen in association with severe pelvic instability.

Zone II (foraminal zone) fractures were associated with neurological deficits in 28.4% of the patients. These neurological deficits were typically associated with lesions of the L-5, S-1, or S-2 nerve roots and often also included bowel and/or bladder dysfunction. All vertical shear injuries assessed involved L-5 with some involving the lumbar plexus and sacral plexus.

Zone III (sacral canal zone) fractures were associated most frequently with neurological deficits, and deficits were seen in 56.7% of patients with fractures in this zone. Within the group of patients with neurological deficits, 76.1% experienced bladder, bowel, and/or sexual dysfunction.

Modifications of the Denis Classification

The Denis Zone III fractures are often divided into 4 types based on the work of Roy-Camille et al.[21] and Strange-Vognsen and Lebech.[25] The Type I fracture is a flexion fracture with anterior angulation of the upper fracture segment. The Type II fracture is also a flexion

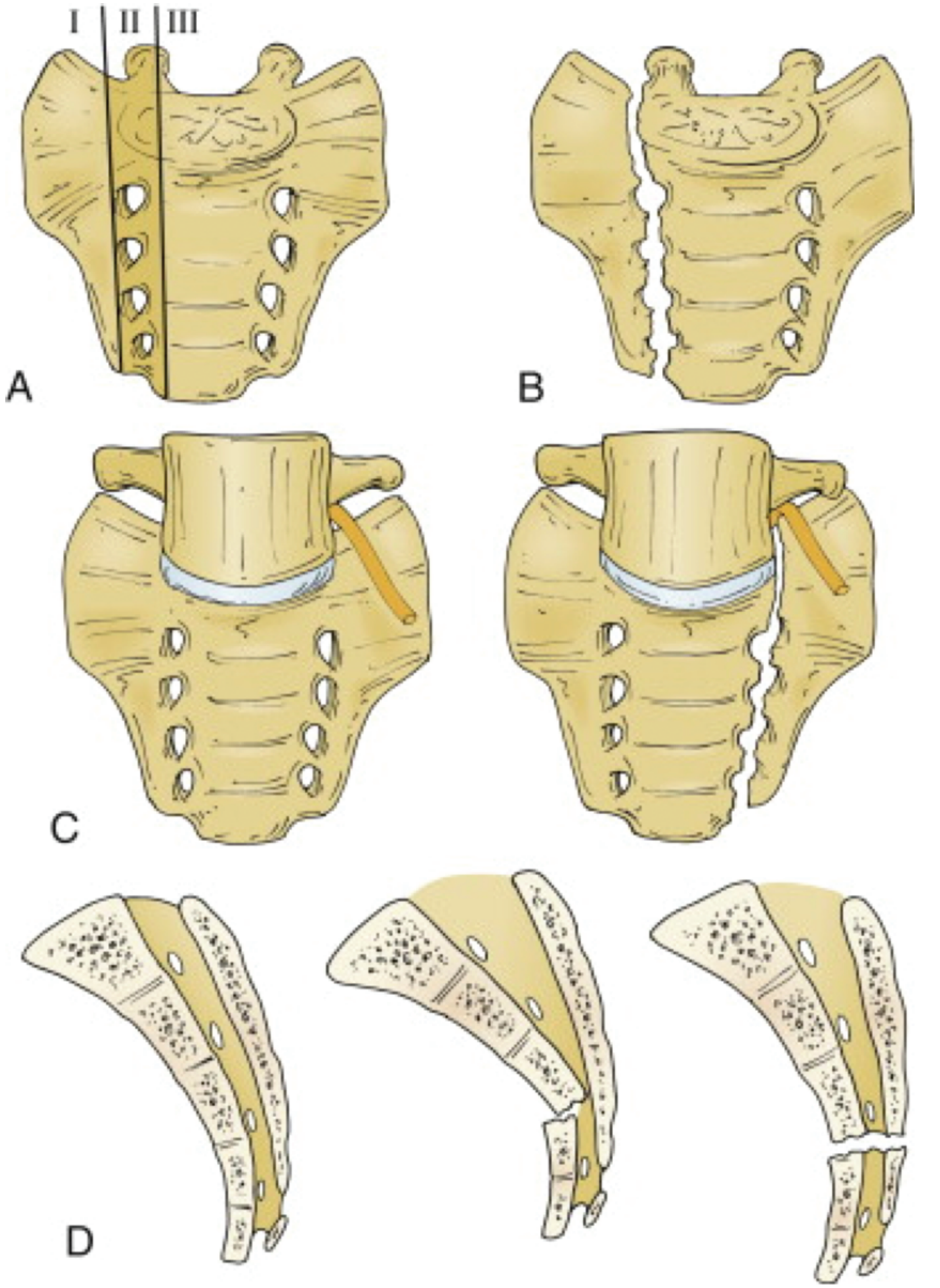

Fig. 4. The Denis classification of sacral fractures. **A:** The 3 zones (Zone I, alar region fracture; Zone II, foraminal region fracture; Zone III, central canal region fracture). **B:** Zone II fracture going through the sacral foramina. **C:** Image showing normal sacral anatomy with reference to the L-5 nerve root *(left)* and a Zone II fracture causing compression of the L-5 nerve root *(right)*. **D:** Sagittal views of normal sacrum *(left)*, a Zone III burst fracture *(middle)*, and a Zone III fracture dislocation *(right)*. Reproduced with permission from Denis F., Davis S., Comfot T. Sacral fractures: an important problem: retrospective analysis of 236 cases. *Clin Orthop Relat Res 227*:67–81, 1988.

fracture, with anterior angulation and posterior displacement of the upper fracture segment. Type III fractures are extension fractures with anterior displacement of the upper fracture segment, causing the upper segment to slide down anterior to the lower segment. The Type IV fracture, resulting from axial loading, is a comminuted fracture of the entire upper segment of the sacrum without displacement of the lower fracture segment; in this fracture type the sacrum remains in neutral alignment.

Sacral Insufficiency Fractures

While most sacral fractures result from high-energy trauma, they may also occur as a result of low-energy trauma or occur spontaneously in patients with osteoporosis. When these fractures occur as a result of low-energy trauma or physiological loads during normal daily activities, they are called "insufficiency fractures." This type of fracture is becoming more common with the increase in life expectancy.

Lumbosacral Dissociation

The lumbosacral junction is surrounded by robust osseous and ligamentous structures; hence, lumbosacral dissociation typically results from high-energy trauma. Lumbosacral dissociation injuries often include a transverse sacral fracture and bilateral vertical fractures.[12]

The lumbosacral injury classification system was developed in 2012 by Lehman et al.[12] This classification system was developed based on 3 injury characteristics: morphology of the injury, integrity of the posterior ligamentous complex, and neurological status. With this classification system a composite injury severity score was calculated using the weighted score from each category and adding these scores together. The calculated score was then used to assist in deciding upon surgical or conservative management. This classification system also has modifiers to assist in determining suitability for operative intervention. The modifiers include systemic injury load, patient physiological status, soft tissue status, and expected time to mobilization. The authors also provide a process for determining the most suitable operative technique.

Illustrative Case

History of Present Illness

A 43-year-old man with a history of traumatic brain injury presented after a fall from about 10 feet in height. The patient was trying to commit suicide by hanging himself. The patient's rope was too long for his platform, and he struck the ground. Upon presentation he complained of neck and back pain. The patient denied urinary or bowel incontinence or retention and also denied sensory deficits and weakness.

Examination

Upon inspection, his right lower extremity was obviously everted and malpositioned. His right lower-extremity strength was difficult to assess because of pain caused by a suspected femur fracture. However, plantar flexion and dorsiflexion were found to be 5/5, and the patient was able to appreciably move the leg.

His left lower-extremity strength was found to be 5/5 in hip flexors, knee flexors, knee extensors, plantar flexors, and dorsiflexors. His toes were downgoing bilaterally. Sensation to light touch was grossly intact in all relevant dermatomes of his legs and arms bilaterally. Further examination revealed intact rectal tone with intact perianal sensation and anal wink. His gait could not be assessed due to severe pain associated with his suspected femur fracture.

Computed tomography imaging revealed a fracture at the right posterolateral aspect of the L-5 vertebral body (Fig. 5), which extended into the right L-5 pedicle, pars, and transverse process. Extensive fractures were also seen in the right portion of the sacrum, limited to Zone I, lateral to the sacral neural foramina in the axial plane (Figs. 5 and 6).

Management

The patient underwent an L-3 to ileum segmental posterior arthrodesis with instrumentation (Fig. 7). The patient also underwent nerve integrity eletrophysiological monitoring, and intraoperative navigation was used for hardware placement.

Nine months postoperatively, a CT scan showed adequate healing of the sacral fracture (Fig. 8).

Clinical Evaluation

Initial management of the patient with high-energy trauma should always follow the ABC guidelines, as vascular injuries associated with pelvic ring or sacral fractures may lead to hemodynamic instability.[26] After initial resuscitation and stabilization, the patient's history should be ascertained from either the patient or the rescue team. Sacral injuries with or without pelvic ring fractures are common in patients undergoing rapid deceleration injuries, such as ejection from motor vehicles (automobiles or motorcycles) or falls from height. The initial physical examination should include visual inspection for ecchymosis along the entire vertebral column, including the sacrum. Palpation should also be done to search for tender points, and it is recommended that the perineal region and anus be assessed for sensory deficits or decreased tone, respectively. Rectal or urethral injuries may also occur following high-energy trauma to the pelvic region; thus, the genitalia should also be assessed.

Insufficiency fractures may occur in elderly patients, especially after previous radiation therapy or as a consequence of osteoporosis. Therefore, elderly patients complaining of lower back or sacral pain should be carefully evaluated. In these situations a technetium-labeled bone scan can be of benefit to properly assess sacral fractures.[14]

Neurological Evaluation

Approximately 15%–40% of patients with a sacral fracture will present with a neurological deficit.[27] However, most patients with a translated transverse fracture will present with a deficit, so a high index of suspicion

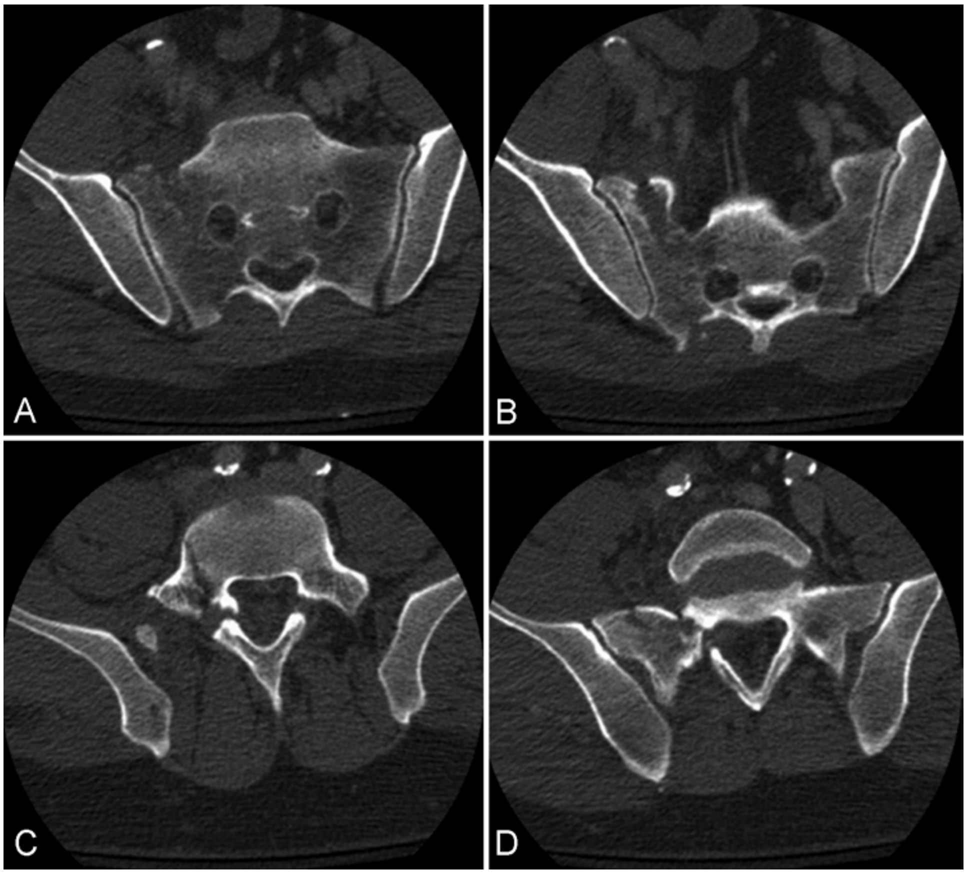

Fig. 5. Initial CT images from illustrative case. A fracture is noted in the right posterolateral aspect of the L-5 vertebral body extending through the right L-5 pedicle, pars, and transverse process **(C)** with further extension into Zone I of the sacrum **(A, B, and D)**.

and thorough evaluation is necessary, especially in patients with multiple body injuries. Although most motor nerve roots innervating the muscles of the lower extremities originate craniad to the sacrum, some sacral fractures may be associated with superior gluteal nerve injuries, causing weakness of hip abduction and internal rotation.[20] Overall, most of the nerves that exit through the sacrum are involved in urogenital and anal sphincter control and perineal sensation. The muscles responsible for anal sphincter control, anal wink, and bulbocavernosus reflex are all innervated via the S2–5 nerves, as well as the parasympathetic input to the inferior hypogastric plexus. Additionally, S-2 (and to a lesser extent S-3 and S-4) is the main root of the pudendal nerve and supplies the striated muscles of the internal and external anal sphincters. The pelvic splanchnic afferent nerves transmit the filling sensation from the bladder, and efferent fibers are involved in the bladder detrusor and rectal contractions. Contraction of the urethral and anal sphincters is done via sympathetic S-2 and S-3 ganglia control.

The Denis classification is useful for estimating the risk of neurological deficit. Zone I fractures are associated with mild neurological deficits in approximately 5.9% of patients and most often affect the sciatic nerve or the L-5 root only.[27] Zone II fractures involve neurological deficits in 28.4% of patients and may cause bowel and/or bladder dysfunction or sciatic nerve injuries (L-5, S-1, or S-2). Displaced Zone I or Zone II fractures may cause the "traumatic far-out syndrome," in which the L-5 root is injured and which is commonly associated with foot drop (Fig. 4C). Lastly, Zone III fractures are accompanied by neurological injuries in over 50% of patients, commonly causing bowel/bladder or sexual dysfunction in these patients.

Imaging Evaluation

Following the Advanced Trauma Life Support (ATLS) guidelines, every patient with high-energy trauma should undergo anteroposterior radiography of the pelvis. However, this imaging modality may not adequately show sacral fractures, with an overall detection rate as low as 30%.[14] For this reason, thin-cut CT scans with coronal and sagittal reconstructions have become the gold standard for the evaluation and diagnosis of sacral fractures.[5,10,11,13] MRI can additionally be helpful in demonstrating areas of neural compression and displacement of fracture fragments.[14]

Elderly patients with suspected insufficiency fractures should be initially evaluated with a technetium-99 bone scan (instead of plain radiography), which will show activity according to the fracture pattern;[7,8,18,19] the standard projections are anterior and posterior. Nonetheless,

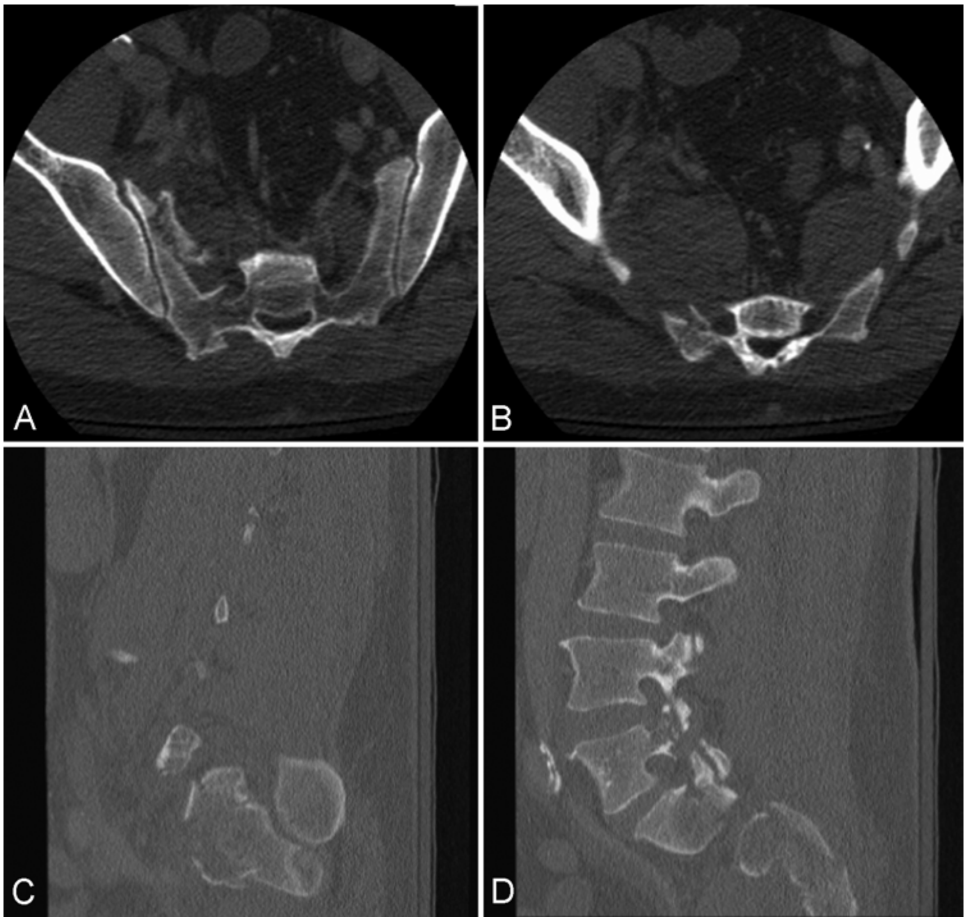

Fig. 6. Initial CT images from illustrative case. An extensive fracture of the sacrum is shown limited to Zone I lateral to the sacral neural foramina in the axial plane **(A and B)**. The sagittal images again re-demonstrate the fracture through the L-5 vertebral body, pedicle, pars, and into the sacral ala **(C and D)**.

bone scanning is not specific, and a CT scan should still be obtained.

Initial and Nonoperative Management

General Principles

Each sacral fracture is unique, and its management should be tailored to the patient's general condition. Early treatment in patients with suspected pelvic and sacral fractures involves immobilization and use of pelvic binders.[20] Life-threatening injuries such as massive retroperitoneal hemorrhage following a pelvic ring fracture should take uttermost priority. In cases in which exsanguinating hemorrhages are present, evacuation of the hematoma via an intraabdominal or anterior approach should be considered.

Sacral fractures are commonly defined as stable or unstable, with unstable fractures being those that are likely to change position or become displaced with physiological loads. Instability is most likely to occur in cases of displacement or disruption of the sacroiliac joints, vertical fractures, and cases of avulsion of the sacrotuberous or sacrospinous ligaments; these types of fractures warrant surgical intervention.[20] On the other hand, many sacral fractures (such as Zone I fractures) can be managed conservatively with bed rest and pelvic immobilization.

Nonoperative Treatment

Minimally displaced fractures (Zone I or II with a stable pelvic ring) may be managed with a short period of bed rest with or without an orthosis; weight bearing is progressively increased afterward. Sometimes, an external fixation device may be used for the anterior portion of the pelvic ring.

Fractures occurring below S-2 rarely cause instability, and immediate operative management is not routinely indicated even in the presence of neurological deficits.[14] Fractures at this level often result in complete nerve root transection, and there are multiple innervations to the bowel and bladder; therefore, early operative exploration/decompression is typically not beneficial. Treatment of these lesions involves immobilization. Patients should be observed for return of function and relief of pain; if this does not occur by 6 months after injury, operative treatment should be considered.

Zone III fractures may be managed conservatively as well. Siebler et al. treated 15 patients with Denis Zone III fractures nonoperatively; the mean duration of follow-up

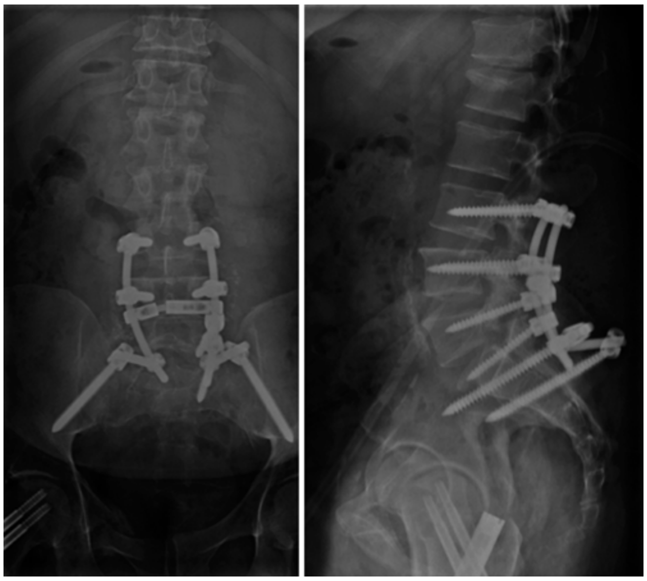

Fig. 7. Postoperative anteroposterior **(left)** and lateral **(right)** radiographs from illustrative case depicting segmental posterior arthrodesis from L-3 to the ileum with instrumentation.

was 43 months. Although all fractures healed, 8 patients had residual bladder, bowel, and/or sexual dysfunction.[24]

Surgical Management

Surgical indications for sacral fractures include: 1) unstable fractures, 2) neurological deficit, and 3) severe axial or sagittal spinal misalignment.[14] Most surgical interventions are based on 1) resection of the distal sacrum, 2) posterior or posterolateral neural decompression, 3) direct reduction and fixation, and 4) reduction and fixation of the lumbosacral spine with lumbopelvic fixation.[14]

Unstable sacral fractures associated with anterior pelvic fractures are usually treated with anterior pelvic fixation or plating. Vertical shear patterns of injury coupled with proximal and posterior migration of the hemipelvis may be life threatening and require emergency surgery.[20] Although initial traction and external pelvic fixation may reduce hemorrhage, this treatment will not stabilize a displaced posterior injury. Patients who present with an L-5 nerve root injury due to a displaced lateral mass of the sacrum may benefit from fragment reduction (which will most likely decompress the root). Pure vertical shear fractures should be treated with early traction on the ipsilateral leg, but if the fragment is displaced more than 2 cm, open reduction and internal fixation should be attempted.[20]

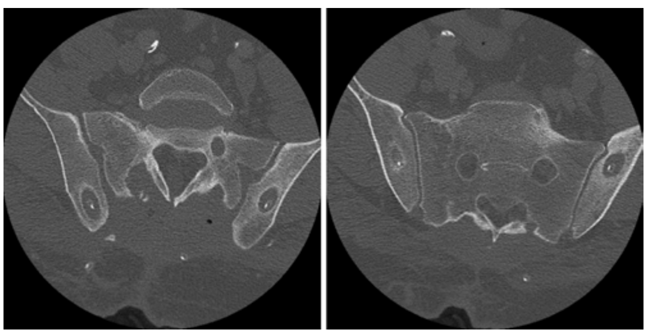

Fig. 8. Nine-month postoperative axial CT images from illustrative case showing adequate bony healing of the sacrum.

Stabilization of the posterior pelvis will indirectly cause posterior stabilization of the sacrum. The use of double cobra plates or threaded rods via posterior tension banding can connect the posterior iliac crests posterior to the sacrum and provide stability.[20] Moreover, this method can be used with anterior fixation or plating.

Stable Zone II fractures may be initially treated with bed rest. Patients with L-5 compression may require early decompression via sacral laminectomy and foraminotomy.[20] Patients with only sciatic pain may require 1 month of bed rest; patients in whom this treatment fails should be offered decompressive surgery. Unstable Zone II fractures, on the other hand, are usually treated with anterior external fixation.[20]

Denis Zone III fractures involve the central canal and, as mentioned previously, are frequently associated with neurological deficits. Low transverse fractures through the S-4 segment are usually treated symptomatically. High transverse fractures are often unstable and require either internal or external stabilization.[20] Patients in whom a neurological deficit is present are best treated with decompression of the spinal canal or nerve roots, with or without fragment reduction and fixation.

Surgical Complications and Outcomes

Few studies to date have specifically evaluated the rate of complications following instrumented fixation of sacral fractures. Bellabarba et al. reported a 16% infection rate, 11% wound complication rate, instrumentation failure in 31% of cases and unplanned reoperation rate of 42%.[1] Nonetheless, the most common problem encountered in patients with sacral fractures is failure of recognition.[14] Elderly patients with lower back pain should receive an MRI or bone scan if a sacral fracture is suspected, and patients with acute trauma should receive a thorough neurological evaluation, including assessment of perineal sensation and sphincter function.

Fusion rates following sacral fractures have been reported to be 85%–90%. However, residual sacral and low-back pain persists in approximately 30% of patients.[17]

Conclusions

The management of sacral fractures remains a challenge for the spine surgeon. Throughout the years, numerous classification systems and fixation techniques have been developed. Currently, although fusion rates remain high, long-term complications, such as residual pain and/or neurological deficits, persist for many patients.

Disclosure

Dr. Gokaslan is the recipient of research grants from DePuy Spine, AOSpine North America, Medtronic, NREF, Integra Life Sciences, and K2M. He receives fellowship support from AOSpine North America and holds stock in Spinal Kinetics and US Spine. Dr.

Trost serves as a consultant for Medtronic. Dr. Lehman is the recipient of research grants from Centinel Spine, DePuy Spine, and the Defense Medical Research and Development Program (DMRDP). The remaining authors have no conflict of interests or funding sources to declare.

Author contributions to the study and manuscript preparation include the following. Conception and design: all authors. Acquisition of data: Bydon, Fredrickson, De la Garza-Ramos, Li. Analysis and interpretation of data: all authors. Drafting the article: all authors. Critically revising the article: all authors. Reviewed submitted version of manuscript: Gokaslan, Bydon, Fredrickson. Approved the final version of the manuscript on behalf of all authors: Gokaslan. Study supervision: Gokaslan, Lehman, Trost.

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Manuscript submitted March 6, 2014.

Accepted May 1, 2014.

Please include this information when citing this paper: DOI: 10.3171/2014.5.FOCUS1474.

Address correspondence to: Ziya L. Gokaslan, M.D., The Johns Hopkins Hospital, 600 N. Wolfe St., Meyer 7-109, Baltimore, MD 21287. email: zgokasl1@jhmi.edu.