Spinal injuries affecting the lumbosacral spine and pelvis

Peter R Loughenbury

Athanasios I Tsirikos

Peter A Millner

Abstract

Lumbo-sacral fractures are complex injuries that often occur alongside pelvic ring trauma. They are often missed on initial assessment and plain radiography, and delayed treatment can lead to pain, reduced mobility and neurological compromise. Careful clinical examination is essential and identification of the fracture pattern often requires CT imaging. A large number of classification systems are available to help guide decision-making and these have recently been summarised in the comprehensive AO Spine sacral fracture classification system. Surgical intervention includes both neurological decompression and stabilisation and is indicated for patients with neurological compromise, lumbo-sacral instability and significant soft tissue injuries.

Keywords lumbar spine fracture; sacral fracture; spinal fracture; spinal injury

Introduction

Lower lumbar and sacral fractures are complex injuries that often occur alongside pelvic ring trauma and therefore require a multidisciplinary approach, including input from the trauma and spinal teams. Sacral fractures can be identified in up to 45% of pelvic ring injuries and rarely occur in isolation (less than 5%).[1] They are frequently missed on initial assessment and present late in up to 30% of cases.[2] 25% have an associated neurological injury due to the proximity of the lumbo-sacral plexus.[1] Denis et al.[2] presented a retrospective series of 236 sacral fractures, one of the largest series in the literature, and found that the chance of identifying a sacral fracture was increased by the presence of an associated neurological injury. In their series, a sacral fracture was correctly identified in 76% of patients presenting with a neurological deficit but only in 51% of those without.

Injury to the lumbosacral complex can occur in young adults due to high-energy trauma, typically as a result of a road traffic collision or a fall from height. In elderly populations, sacral insufficiency fractures may also occur as a result of low energy falls. In both groups, the presence of a neurological deficit predicts a poor long-term outcome and can lead to persistent pain, reduced mobility and neurological dysfunction.

Anatomy

The sacrum is the base of the spinal column and provides a connection to the pelvic ring, allowing transfer of weight to the lower limbs. It is adapted to transmit load as a large fused triangular bone with strong osseo-ligamentous connections to the pelvic ring. It articulates with the L5 vertebra proximally, the coccyx distally and the ilium laterally through the sacroiliac joints. At birth the five sacral vertebrae are mobile and start to ossify towards the end of the first year of life. Each level has five ossification centres and there are an additional ten ossification centres that form the lateral part of the sacrum.[3] Fusion of the sacrum begins during adolescence, in a caudal to cranial direction, and is complete by early adult life.[3] The age at which the sacrum is fully fused depends on the pattern of load bearing experienced in the region. The sacrum has a concave anterior and convex posterior surface. The apex is angled posteriorly to increase the size of the pelvic cavity. The angle formed between the lumbar spine and sacrum is the sacral promontory. This is approximately 20° at birth and increases to around 70° in adulthood.[3] The sacral promontory forms a palpable ridge that is a useful landmark during anterior surgical approaches to this region. The sacrum itself is kyphotic with a forward angulation in the sagittal plane of 0–90°. The relationship between the sacrum and the pelvis drives the overall alignment of the spinal column. The inclination of the sacrum is intimately related to the position of the pelvis and compensatory lordosis in the lumbar spine.[4] The sacrum also provides protection for the lumbo-sacral (L4-S1) and sacral (S2–4) plexuses, as well as the iliac vessels.

Efficient transfer of load from the trunk to the lower limbs is achieved through the articulation of the first sacral vertebra with the iliac wings (the sacro-iliac joints) and to the acetabulae. Strong lumbo-sacral and lumbo-iliac ligaments stabilise the sacroiliac joints. Although there are large areas of muscular attachment on the posterior aspect of the sacrum, there is very little muscle bulk and a poorly developed lumbosacral fascia. This makes the area vulnerable to trauma and wound problems, and can also limit the use of bulky implant systems that may be prominent and lead to soft tissue irritation.

The sacral spinal canal is large and transmits the nerve roots of the cauda equina. The S1–S4 nerve roots are transmitted through the bilateral sacral foramina. The L5 nerve roots exit the L5/S1 inter-vertebral foramina and run on top of the sacral ala. The S1 nerve root occupies one third of the foramen.[5] Below this level there is a progressively increasing space for the nerve roots with the S4 root occupying one sixth of the foramen.[5] This contributes to the higher rate of injury seen in the S1 and S2 nerve roots. The anterior rami of the lower sacral nerve roots provide parasympathetic supply to the bladder and rectum, as well as contributing to the sympathetic ganglia of the hypogastric plexus, which extends caudally along the medial margins of the sacral foramina. In this way they contribute to bladder, bowel and sexual function. The posterior rami are sensory only and

Peter R Loughenbury *MSc PG Cert Med Ed FRCS (Tr & Orth) Spinal Fellow, Scottish National Spinal Deformity Centre, Royal Hospital for Sick Children, Edinburgh, UK. Conflicts of interest: none.*

Athanasios I Tsirikos *MD FRCS PhD Consultant Orthopaedic and Spine Surgeon and Honorary Clinical Senior Lecturer, University of Edinburgh/Royal Hospital for Sick Children, Scottish National Spinal Deformity Centre, Edinburgh, UK. Conflicts of interest: none.*

Peter A Millner *BSc FRCS (Orth) Consultant Spinal Surgeon, Leeds Centre for Neurosciences, Leeds General Infirmary, Leeds, UK. Conflicts of interest: none.*

Please cite this article in press as: Loughenbury PR, et al., Spinal injuries affecting the lumbosacral spine and pelvis, Orthopaedics and Trauma (2016), http://dx.doi.org/10.1016/j.mporth.2016.07.007

contribute to the cluneal nerves. Unilateral preservation of the nerves is sufficient for adequate control of bladder and bowel function.

Clinical assessment

Injury to the lumbo-sacral complex should be considered in any trauma patient reporting peri-pelvic pain. The mechanism of injury is usually high-energy and due to a road traffic collision or a fall from height. Fragility fractures may also occur where there is poor bone quality due to an underlying condition such as osteoporosis, or in the elderly.

Examination should include inspection of the skin and soft tissue throughout the entire pelvis. Lacerations, ecchymosis or swelling in the soft tissues surrounding the pelvis suggest an underlying fracture. Palpation may reveal tenderness or a bony sacral prominence due to a displaced fracture. There may also be palpable subcutaneous fluid indicating a lumbo-sacral fascia degloving injury – a Morel-Lavallee lesion.[6] Neurological examination includes a full rectal examination with assessment of voluntary sphincter contraction, light touch and pinprick sensation in the S2–S5 dermatomes. Specific reflexes should be examined including assessment of the peri-anal wink and bulbocavernosus and cremasteric reflexes. Female patients should also have a vaginal examination to rule out an open injury. Pelvic stability should be assessed by internally and externally rotating the iliac blades. Finally, there should be an assessment of the lower limb vascular supply, including all lower limb pulses and any further vascular imaging that may be required.

Imaging

Plain radiographs reliably identify up to 30% of sacral fractures.[7] The lateral sacral view provides the best assessment of the fracture morphology. Antero-posterior imaging is also possible but the posterior inclination of the sacrum limits the information that can be gained by this study. Pelvic inlet and outlet views can be more useful as the outlet view provides a clearer antero-posterior image of the sacrum while the inlet view allows visualisation of the sacral dome and spinal canal.[8] The 'Ferguson' view is a centrally coned-down modification of the pelvic outlet view that is directed perpendicular to the sacral inclination and, therefore, provides a direct visualisation of the entire sacrum.[8] Concomitant lower lumbar injuries (often transverse process fractures) and pelvic ring fractures are often seen.

The British Orthopaedic Association Standards for Trauma (BOAST) guidelines[9] from 2008 identify that sacral injuries are often adequately imaged as part of the CT scans of the pelvis undertaken as part of the modern CT trauma series (<5 mm slices). Sagittal and coronal reformatting allow for better visualisation of the lumbo-sacral junction and identification of the fracture pattern. An MRI is indicated whenever there is suspicion of a neurological injury. CT myelography is of limited use, as the thecal sac terminates at the level of the S1/S2 space. Where there is persistent neurological deficit after an injury, repeat MRI and electrophysiology (peri-anal somatosensory evoked potentials and anal sphincter myography) can help differentiate between neurological sequelae and trauma to the rectum or urinary tract.

Classification

The pattern of injury seen in fractures of the lumbo-sacral junction depends largely on the mechanism of injury. A fall from height typically presents with a transverse sacral injury and associated lumbar fractures, while a lateral compression pattern is more often seen following a road traffic collision. There is often an associated pelvic ring injury and the fracture pattern can, therefore, be included in a wider pelvic injury classification (Tile, Young-Burgess).[10] Alternatively, several authors have attempted to classify sacral fracture types and patterns of injury across the lumbosacral junction.[2,11–15]

Denis et al.[2] suggested a 3-zone classification system in 1988 and this remains the standard anatomical classification system for sacral fractures. They evaluated a retrospective series of 236 sacral fractures in 776 patients with pelvic injury, and suggested a system of three zones based on the sacral neural foramina (Figure 1). Zone 1 fractures are lateral to the neural foramina; zone 2 fractures occur through the neural foramina; zone 3 fractures involve the spinal canal. The three different zones were identified as having classic clinical presentations:

- *Zone 1* fractures are the most common (50%) and neurological injury occurs in approximately 6% of patients, typically involving the L4 or L5 nerve roots.
- *Zone 2* fractures are the second most common (34%) and involve a fracture through the neural foramen without compromise of the spinal canal. Neurological compromise is more common (28%) and involves the L5, S1 or S2 nerve roots. A distinction should be made between stable and unstable zone 2 fracture patterns. If there is a vertical shear component this should be considered unstable and is associated with a poor functional outcome and a high rate of non-union.
- *Zone 3* fractures are uncommon (16%) and involve a fracture that extends medial to the neural foramina into the spinal canal. They are associated with the highest prevalence and severity of neurological injury, which affected 57% of patients in their series. Bladder, bowel and sexual dysfunction were noted in 76% of patients with a neurological deficit in this group.

The Denis classification remains the standard system because it is clear, reproducible and directly linked to an assessment of neurological outcome. In clinical practice, the fracture patterns in zone 3 injuries can be more complex and involve bilateral

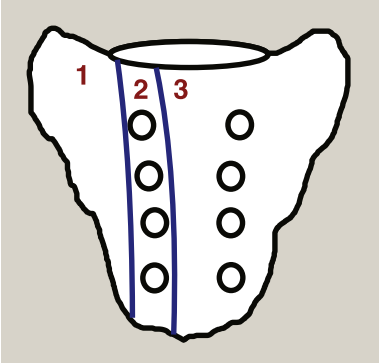

Figure 1 Denis classification of sacral fractures.[2]

Please cite this article in press as: Loughenbury PR, et al., Spinal injuries affecting the lumbosacral spine and pelvis, Orthopaedics and Trauma (2016), http://dx.doi.org/10.1016/j.mporth.2016.07.007