Transverse sacral fractures with anterior displacement

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Abstract Transverse fractures of the sacrum with anterior displacement are the rarest type of transverse sacral fractures. They usually occur at the S1–S2 region in suicide jumpers. A clinical study was performed to evaluate the diagnosis, treatment and outcome of transverse sacral fractures with anterior displacement. We present six patients with a transverse fracture of the sacrum with anterior displacement. All patients presented with bowel and bladder dysfunction, perineal anesthesia, sensory and motor deficits at the lower extremities. Prompt diagnosis of the sacral fracture was obtained in five of the six patients. Operative treatment including lumbosacral laminectomies, spine instrumentation and fusion was done in all patients. Neurological recovery was almost complete in one patient, incomplete in four patients, and none in one patient. Although reduction of the fracture was not ideal in many of these patients, long-term clinical and radiographic follow-up, and neurological improvement were rewarding.

Keywords Sacral fractures · Transverse · Anterior displacement

Introduction

Isolated fractures of the sacrum are rare. They are usually associated with fractures of the pelvic ring [1–4], or rarely as isolated injuries [1, 5, 6]. Many studies have attempted

to describe and classify the fractures of the sacrum. Initial report is attributed to Malgaine in 1847, while Bonin [7] was one of the first to attempt to characterize these injuries into six different types. Schmidek et al. [8] classified sacral fractures into indirect and direct patterns, while Sabiston and Wing [9] suggested a simpler classification of sacral fractures into transverse (at the level or below the sacroiliac joint) and vertical.

Most sacral fractures are vertical [2, 4]. Transverse fractures of the sacrum account for approximately 5–16% of all sacral fractures [3, 4, 8]; pelvic fractures are associated with only 28% of transverse sacral fractures [4]. Isolated sacral fractures represent 5–10% of all sacral injuries [6]; these fractures tend to be transverse [3]. Transverse sacral fractures usually result from high-energy injuries such as motor vehicle accidents and falling from height onto the lower extremities, especially in suicide jumpers [10]. Roy-Camille et al. [10] in a clinical and cadaveric study reported three distinct types of transverse sacral fractures. Type 1 fracture is a flexion injury with an anterior simple bending of the upper sacrum fragments; type 2 fracture is a flexion fracture with a posterior displacement of the upper sacrum that becomes more or less horizontal and settles on the fractured surface of the lower fragment; type 3 fracture is an extension fracture with anterior displacement of the upper fragment more or less vertical that slips downward in front of the lower fragment.

Treatment of transverse sacral fractures is difficult, both for reduction and stabilization. These fractures have been treated operatively and non-operatively using different surgical procedures and techniques [1, 10–14]. The purpose of this study is to present six patients with a transverse fracture of the sacrum with anterior displacement, and to emphasize the need for a comprehensive neurological examination and adequate imaging studies. To our

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knowledge, although a small number, we believe that this is one of the largest series in the literature that reports on Roy-Camille type 3 fractures of the sacrum.

Patients and methods

Since 1983, six severely injured patients were admitted and treated at the authors' institution for a transverse fracture of the sacrum with anterior displacement (Table 1). There were five females and one male, aged 15–37 years. Five patients were admitted after falling from height; one was an accidental fall (patient 1) and the other four were attempted suicides (patients 2, 4, 5, and 6). One patient (patient 3) had a working accident (squashed by an agricultural tractor). The fracture occurred at the S1–S2 region in all cases. All the patients were under the care of the senior authors, and gave their informed consent to be included in this study (Figs. 1, 2).

Results

Initial clinical data of the six patients included in this study are shown in Table 1. At admission, plain radiographs and/or computed tomography scans of the pelvis and lumbar spine revealed the fracture of the sacrum in all but one patient (patient 4). Associated injuries of the abdomen were present in three patients (patients 1, 4, and 6). In these patients, a laparotomy was necessary for intraperitoneal bleeding, spleen and kidney injury, and mesenteric tear prior to the surgical operation for the sacral fracture. The fractures of the extremities were treated, a few days after the surgical operation to the sacrum.

The surgical operation for the sacral fracture was performed at admission on two patients (patients 1 and 3). In patients 2, 5, and 6, the surgical operation was done soon after the patients had been hemodynamically stable; this was at 7–15 days after the injury. Through a posterior approach, L4–S1 laminectomies were done. Intraoperative findings

Table 1 Data of the six patients with a transverse fracture of the sacrum with anterior displacement

Patient	Age/ gender	Mechanism of injury	Neurological deficits at admission	Delay to surgery	Sacral fracture treatment	Follow-up	Recovery and outcome
1	15/F	Accidental fall	Bowel and bladder dysfunction; saddle anesthesia; incomplete L5 and S1 paraplegia	0	L4–S1 laminectomies; autologous bone grafting	15 years	Almost complete
2	37/F	Fall from height— suicide attempt	Bowel and bladder dysfunction; saddle anesthesia; incomplete L5 and S1 paraplegia	10 days	L4–S1 laminectomies; Harrington rods-sacral bar; autologous bone grafting	24 years	Incomplete
3	15/M	Work accident	Bowel and bladder dysfunction; saddle anesthesia; incomplete L5 and S1 paraplegia	0	L4–S1 laminectomies; Hartshill frame; bone grafting	16 years	Incomplete (at 2 months)
4	22/F	Fall from height— suicide attempt	Not evaluated	6 weeks	L4–S1 laminectomies; Harrington rods and hooks; bone grafting	7 years	Incomplete
5	14/F	Fall from height— suicide attempt	Bowel and bladder dysfunction; saddle anesthesia; incomplete L4–S1 paraplegia	7 days	L4–S1 laminectomies; titanium rods and transpedicular screws; bone grafting	5 years	Incomplete; second suicide attempt at 2 years
6	20/F	Fall from height— suicide attempt	Bowel and bladder dysfunction; saddle anesthesia; complete L4–S1 paraplegia	15 days	L4–S1 laminectomies; titanium rods and transpedicular screws; bone grafting	2 months	None

Fig. 1 **a** Anteroposterior radiograph of the pelvis of a 14-year-old girl with a transverse fracture of the sacrum with anterior displacement after fall from height for attempted suicide (patient 5). **b** Intraoperative photographs showing L4–S1 laminectomies, repair of the dura tear, and internal fixation using a rods and screws instrumentation system. Postoperatively, the patient had incomplete neurological improvement. **c** Anteroposterior (left) and lateral (right) postoperative radiographs

included spinal canal occlusion, dural tears, and transection of S1 sacral roots in all patients. Spinal instrumentation devices including sacral bars, Harrington rods, Hartshill frame, and transpedicular screws and titanium rods have

Fig. 2 **a** Anteroposterior (left) and lateral (right) radiographs of the pelvis of a 22-year-old woman who was admitted after fall from height for attempted suicide (patient 4). The sacral fracture on the lateral radiograph (arrows) has been initially misdiagnosed. **b** Six weeks after the injury, clinical and neurological examination showed incomplete L5 and S1 paraplegia and diminished sphincter control. T1-weighted (left) and T2-weighted (right) magnetic resonance imaging revealed a transverse fracture at the S1–S2 region with anterior displacement. **c** Operative treatment including open reduction of the fracture and stabilization using Harrington rods and hooks was done at that time. Postoperatively, the patient had incomplete neurological improvement

been used in all patients except patient 1 (Table 1). In this patient, laminectomies, reduction of the fracture, and bone grafting were done without instrumentation. A serious postoperative complication was noticed in patient 3. In this

patient, a few hours after initial surgery, an emergency operation was performed because of a large hematoma over the cauda equina and nerve roots. The instrumentation previously applied was removed, the laminae of S1 and S2 were excised and the fragments of the sacral fracture were osteosynthesized using a system of plates and screws.

Patient 4 had open fractures of both tibiae, fractures of the tarsal bones and calcanei in both feet, and intraperitoneal bleeding; neurological symptoms and signs were not estimated and recognized. Rectal examination was not done, and control of the urethral sphincter was not evaluated at that time because a urethral catheter had been applied at admission. Surgical operations have been performed for the abdominal injuries and for the management of the fractures of the legs and feet. Six weeks after the injury, clinical and neurological examination showed incomplete L5 and S1 paraplegia and diminished sphincter control. Magnetic resonance imaging revealed a transverse fracture at the S1–S2 region with anterior displacement; surgical operation including L4–S1 laminectomies and instrumented fusion using Harrington rods and hooks, and bone grafting was performed at that time.

Postoperative follow-up ranged from 2 months to 24 years. All patients were included at the postoperative follow-up. Patient 6 was not included in the outcome analysis because of the short (2 month) follow-up.

Postoperative recovery was uneventful in all patients. Neurological recovery including bowel and bladder function, perineal sensation, and sensory-motor control of the affected nerve roots at the lower extremities was observed in all patients except patient 6. At 2-month follow-up, patient 6 showed no neurological improvement. Patient 3 showed neurological improvement at 2 months after the operation (Table 1).

All patients were discharged from hospital approximately 6–8 weeks after the operation with a custom-made thermoplastic lumbosacral orthosis for another 8 weeks and instructions for physical therapy and rehabilitation programs. One patient (patient 5), a year later had the spinal implants removed because of skin pressure and pain during sitting. This patient, 2 years later had been operated again for thoracolumbar spine fractures because of a second suicide attempt.

Discussion

Transverse fractures of the sacrum with anterior displacement are the rarest type of transverse sacral fractures. They usually occur at the S1–S2 region [5, 6, 10–13] in suicide jumpers [10]. The mechanism of injury in patients admitted after falling from height is lordosis of the lumbar spine with extension of both hips at the time of landing [10].

Neurological symptoms and signs including bowel and bladder dysfunction and perineal sensory deficits are frequently associated with these fractures because of the nerve injury to the sacral nerve roots [1, 4–6, 9, 10, 13]. In addition, motor and sensory deficits at the L4–S1 dermatomes and myotomes at the lower extremities can also be observed [5, 14]. These deficits may be due to the lumbosacral nerve root compression or traction injury stretching of the lumbosacral plexus caused by the fracture displacement [15]. In our series, at initial presentation, all patients had weak or diminished sphincter control and bowel and bladder dysfunction, perineal sensory deficits, and variable sensory and motor deficits at the lower extremities. However, although not completely recovered, these have been significantly improved in five of the six patients after surgical treatment.

Initial diagnosis of transverse sacral fractures with anterior displacement is usually very difficult on plain radiographs [2, 4, 5, 8, 14, 16–19]. Spinal radiographs do not give a good image of the sacrum [2, 4, 5, 14, 19], and plain radiographs performed at the emergency department are mostly of poor quality [6, 10]. Patients with suspected sacral fracture require specific sacral views. Radiographic findings that should be evaluated include the symmetry of the sacral foramina and arcuate lines, the trabeculation of the lateral masses, and the associated low lumbar transverse process fractures. Transverse sacral fractures may also be missed on computer tomography scans because the fracture is parallel to the axial cuts and thus may not be well visualized, and require sagittal reconstruction. The most predictable method of visualization for this particular type of sacral fractures seems to be magnetic resonance imaging [6]. In the present series, prompt diagnosis of the sacral fracture has been obtained at initial admission and treatment proceeded in all patients except patient 4. In this patient, poor quality of the initial radiographs, associated fractures of both tibiae and calcanei, and compromised general health status led to difficulty in recognition of the patient's neurological status.

Delay in diagnosis and treatment of transverse sacral fractures can lead to neurological deterioration, persistent deformity, and pain. However, there is no agreement between the authors dealing with sacral fractures regarding treatment for this type of fracture [4, 9, 10, 12–14, 20, 21]. Also, the lack of literature evidence supporting surgical decompression for a better neurological outcome, and the absence of satisfactory surgical techniques to treat these injuries have led some authors to advocate non-operative treatment [21].

Transverse fractures of the sacrum have been treated operatively and non-operatively [10, 13, 14, 22, 23]. Patients, especially children and adolescents with sacral fractures and minimal or absent neurological deficits can be

managed conservatively with bed rest, traction, and bracing for supportive postural treatment until fracture healing [13, 14, 23]. Closed reduction of the sacral fracture can be achieved by a heavy two-pole traction through the lower extremities and the axillas, and anterior tilting of the pelvis [10, 13]. The quality of the reduction is assessed by the lateral radiographs of the sacrum. Subsequently, the patient should be positioned with the hips and knees flexed to 90° to maintain the achieved reduction, while remaining in traction [13]. Once reduction and restoration of the sagittal alignment at the lumbosacral junction and the sacrum has been achieved, conservative management may be implemented. However, because the fracture-dislocation of the sacrum is highly unstable, loss of reduction may occur over time. In the case of failure of closed reduction, open reduction, decompression, and stabilization should not be delayed [10, 13].

Surgical indications for anteriorly displaced transverse sacral fractures include displacement of the fracture [10], neurological deficits or deterioration after non-operative treatment, instability, and severe sagittal or coronal spinal malalignment [1, 3, 5, 18, 22–25]. Surgical intervention provides for early decompression of the lumbosacral nerve roots, repair of the dura mater ruptures and nerve tissue, lysis of adhesions, and open reduction and stabilization of the fracture using spinal instrumentation systems [1, 11, 22, 23]. Ruptures of the dura mater should be restored to avoid the creation of a cerebrospinal fistula [23]. Reduction of the fracture and maintenance of the sagittal alignment is critical for the normal weight-bearing axis of the body [6].

The presence of neurological deficits makes treatment challenging because of the question of surgical decompression [10, 13, 14, 22, 23]. A significant portion of nerve injuries is root avulsions and the remainder is compression injuries and neurapraxias that frequently respond to non-operative treatment [14]. Some authors advocate routine lumbosacral decompression for sacral fractures associated with neurological deficits [1, 10, 11, 22, 23]. Others have recommended conservative treatment including bed rest with or without traction because intraoperative findings have shown torn, stretched, contused or lacerated nerve roots [9, 14, 20]. The proponents of non-operative treatment believe that spinal nerves have the ability to restore their function progressively during a period of 12–18 months [20]. Although transection or contusion of nerve roots, or neurotmesis cannot recover [4, 9, 14, 20], the goal of surgery is to achieve decompression allowing potentially viable nerve roots to recover [4].

At the lumbosacral junction, the body weight is transferred from the sacrum across the sacroiliac joints to the pelvis, connecting the axial and appendicular skeletons [6]. High transverse sacral fractures with anterior displacement of the upper sacrum are unstable because the fracture fragment containing the sacroiliac

joint is floating with respect to the rest of the pelvis [4, 8, 13, 21, 26]. Unstable sacral fractures represent severe injuries accompanied by a high mortality and morbidity due to pain and malunion [21, 26]. As in the present series, patients with unstable sacral fractures should undergo internal fixation [4, 10, 21]. Although difficult because of the thin and cancellous architecture of the sacrum and probable comminution of the fracture, stabilization of the fracture should be attempted through posterolateral spinal instrumentation and fusion [27–29] augmented with bone grafting to induce bone healing, allow early mobilization, and facilitate nursing care of the patients. Early surgical operation prevents delayed neurological deficits by inhibiting the formation of a large callus, evacuating the hematoma and impeding the movement of bone fragments [1, 5, 11, 22, 23].

Due to the low incidence of these injuries, there is no literature evidence on the management of transverse sacral fractures with anterior displacement. In the present series, extensive lumbosacral laminectomies were performed in all patients to enhance neurological recovery and facilitate the reduction and internal fixation of the fracture. This series is small and different treatment modalities are not compared due to the nature and size of the group. Although reduction of the fracture was not ideal in many of these patients, long-term clinical and radiographic follow-up, and neurological improvement were rewarding.

Conclusion

Transverse fractures of the sacrum with anterior displacement are rare, difficult to recognize and frequently misdiagnosed. All patients with these types of fractures show weakened or diminished sphincter control and bowel and bladder dysfunction, and almost all patients show sensory and motor deficits at the lower extremities. Clinical suspicion of these types of sacral fractures especially in suicide jumpers should lead to thorough clinical and neurological examination of the patients, careful evaluation of plain radiographs of the pelvis and specific sacral views, and use of ancillary imaging studies.

Operative treatment using lumbosacral decompression by laminectomies, dural repair, and posterolateral instrumented fusion and bone grafting is recommended to achieve maximum neurological improvement and a more favorable clinical outcome.

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