Open reduction and posterior instrumentation of Type 3 high transverse sacral fracture-dislocation

Technical note

Konstantinos A. Starantzis, M.D.,¹ Babak Mirzashahi, M.D.,² Eyal Behrbalk, M.D.,¹ Mirmostafa Sadat, M.D.,² and Masood Shafafy, F.R.C.S.(Tr&Orth)¹

¹Nottingham University Hospital, Centre for Spinal Studies and Surgery, Queens Medical Centre, Nottingham, United Kingdom; and ²Imam University Hospital, Tehran University of Medical Sciences, Tehran, Iran

The authors describe an open reduction and fixation through a posterior approach of Roy-Camille Type 3 transverse sacral fractures. This technique involves posterior staged reduction of the fracture applying distraction forces to restore the height, followed by posterior translation to restore sagittal alignment. Tips and pearls of this procedure, described for the first time in the literature, are also discussed in this report.

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Key Words • transverse sacral fracture • reduction • surgical treatment • posterior instrumentation • trauma • technique

Transverse sacral fractures (TSFs) were first described in 1945.¹ However, nomenclature over the years has been confusing and included terms such as “sacral fracture-dislocations,” “displaced transverse sacral fracture,” “traumatic sacrolisthesis,” and “suicidal jumper’s fracture.” Roy-Camille et al.¹⁷ classified TSFs into three types, and later a fourth type was added.²⁴ Type 1 fractures are angulated but not translated (the two fragments remain in continuity). In Type 2 injuries the proximal sacrum fragment becomes horizontal and slips backward, while in Type 3 injuries there is complete anterior translation of the proximal fragment that slips down in front of the caudal fragment. Type 4 fractures are segmentally comminuted as a result of an axial compression type of injury.

This is a technical note on open reduction and posterior instrumentation of Type 3 high transverse sacral fracture-dislocation. To the best of our knowledge, this procedure has never been described in the literature.

Illustrative Case

History and Examination. A 36-year-old male laborer presented to the Accident and Emergency department after a heavy metallic object was accidentally released approximately 3 m over his body while he was operating a machine in the sitting position. The heavy object landed directly on his lower back, as he instinctively bent his body forward to protect his head. On arrival the patient was alert, oriented, hemodynamically stable, and cooperative. He was complaining of severe pain over his lower back and sacrum. After our initial examination and since the patient was stable, we logrolled him, which revealed ecchymosis and edematous skin over his lower lumbar-lumbosacral spine that was significantly tethered. The described area was tender on palpation both over the axial spine and the paraspinal muscles. Lower limb neurological examination did not show any kind of motor or sensory deficit, and his reflexes were normal and symmetrical. Rectal examination was painful but normal. When catheterized the patient was able to feel the catheter and maintained a positive catheter tag until it was finally removed.

Primary imaging studies and a CT scan with coronal, sagittal (Fig. 1), and 3D reconstructions were obtained and, given the patient’s neurological status, surprisingly demonstrated an S1–2 Roy-Camille Type 3 fracture-dislocation.

Operation. A new technique of open reduction and posterior instrumentation was performed.

Abbreviation used in this paper: TSF = transverse sacral fracture.
Postoperative Course. The patient made an uneventful recovery and was discharged on the 4th postoperative day. Postoperative imaging studies (Fig. 2) were satisfactory, and no neurological deficit was recorded by the day he was discharged. He managed to walk using two crutches on the second postoperative day. He had a successful trial without catheter on the same day, and he had opened his bowels prior to his discharge.

One year following his injury, the wound had healed nicely, and he remained neurologically intact with good control of his bowel and bladder. Occasionally, he suffers from burning sensation over the plantar surfaces of his feet, but other than that he remains asymptomatic. Radiographs are entirely satisfactory (Fig. 3), and he returned to his work as a supervisor.

Surgical Technique

Under general anesthesia, muscle relaxation, and continuous intraoperative neuromonitoring, the patient is positioned prone with extra caution to prevent any neurological compromise. The hips and knees are positioned in slight flexion in an attempt to achieve indirect reduction of the fracture and, at the same time, to relax the tension of the sciatic nerves. A standard midline posterior approach to the spine from L-3 to S-3 is performed.

Intraoperative findings typically include a large hematoma surrounded by necrotic tissues that should be thoroughly debrided and irrigated. Access to L-5 and S-1 anatomical landmarks is impossible at this stage because of the anterior translation and shortening, which literally resulted from diving of the proximal fracture segment down in front of the distal one. Hence, monoaxial (preferably) pedicle screws are inserted in L-4 bilaterally followed by polyaxial iliac screws through the posterior superior iliac spine. The rationale for the reduction is to apply distraction forces between the two screw posts in the L-4 and iliac crests. Once the height is restored, the anterior translation is gradually reduced using the L-4...
screw, with a reduction tower/persuader in situ for the pivoting maneuver around the iliac screw, which acts as a post. To achieve this, a temporary rod is used on the left with the iliac screw fully locked onto the rod. A rod holder can optionally be placed close to the L-4 screw with the reducer (persuader) in situ to maximize the working distance of the distractor. A distractor is then used between the L-4 screw–reduction tower complex and the rod holder to restore the height of the spinal column (Fig. 4A). As soon as this is achieved, the assistant starts tightening the persuader onto the L-4 screw (Fig. 4B) to reduce the anterior translation of the fracture back to partially restored alignment (Fig. 4C). Following this partial reduction of S-1 on S-2, the anatomical landmarks of L-5 become more accessible, and a polyaxial screw is inserted on the right (Fig. 4D). Reduction is fostered with a permanent rod inserted on the right, and the temporary rod is then removed on the left, allowing a left L-5 pedicle screw insertion with subsequent permanent rod fixation on the left. With the permanent rods and the L-5 screws in situ, we continue with reduction of the translation until we achieve normal sagittal alignment (Fig. 4E). In the presence of any preexisting neurological deficit, additional decompression via an extended laminectomy could be performed at this stage. Final tightening is then followed by bone grafting (local bone and allograft placed in between fractured transverse processes and de-corticated L5–S1 laminae and S-1 transverse processes

![Fig. 4. Photographs demonstrating technique on a model.](image-url)

- **A:** A distractor is used to restore the height of the spinal column.
- **B:** The assistant starts tightening the reduction tower.
- **C:** Anterior translation of the fracture is gradually reduced.
- **D:** Partial reduction of S1–2 reveals the anatomical landmarks of L-5, and a pedicle screw is inserted in the contralateral L-5 pedicle.
- **E:** Full reduction using both permanent rods and the L-5 screws in situ until a normal sagittal alignment is achieved.
Type 3 transverse sacral fractures

bilaterally) and wound closure in layers with two suction drains. Simplified step-by-step diagrams of the technique are provided in Fig. 5.

Discussion

Transverse fractures of the sacrum have been treated both surgically and nonsurgically. Candidates for nonsurgical treatment are patients with sacral fractures and absent or minimal neurological deficit that can be managed with bed rest, traction, and bracing until fracture healing. Indications for surgical treatment include, but are not limited to, neurological impairment or deterioration after nonoperative treatment, mechanical instability, and major sagittal malalignment of the spinal column.

The treatment of Type 3 TSFs remains challenging with regard to both reduction and stabilization. Since this entity is actually uncommon, most spinal surgeons have limited experience with the management of and surgical strategy for this type of injury. Traditionally, these fractures have been addressed using different surgical procedures and techniques. In the absence of clear robust evidence and guidelines, treatment is usually selected based on individual surgeon preferences and experience rather than an evidence-based approach and strategy.

Since Type 3 fractures are almost always associated with neurological deficit, the most commonly performed procedure is an extensive laminectomy for decompression. Most authors support routine decompression for sacral fractures associated with neurological deficits. Although transection or avulsion of the nerve roots cannot recover, the goal of surgery is to achieve decompression, allowing potentially viable nerve roots to recover. However, others have recommended conservative treatment in light of intraoperative findings showing torn, stretched,

![Diagrams of the surgical technique. Right (R) and left (L) sides demonstrated separately during the phases of the procedure.](image-url)
confused, or lacerated nerve roots. These same authors suggest nonoperative treatment, as they believe that the viable spinal nerves have the ability to restore their function progressively during a period of 12–18 months.

A few surgeons have advocated reduction to restore sagittal alignment and reduce stretching of the nerve roots—especially those above the level of the fracture. Indirect closed reduction is almost impossible in Type 3 injuries because of the fracture overlapping. Direct anterior reduction carries the usual risks of anterior surgery compromised by the distorted anatomy of the major vessel tethered by the displaced fragments. Moreover, direct visualization and control of the neural canal is impossible from this approach. Theoretically, posterior reduction can circumvent the aforementioned disadvantages, but both the reduction maneuvers and posts are limited. Hence, historically, reduction has been a lower priority, and in situ stabilization was instead performed in most of the previous reports.

In terms of stabilization, various tools have been used, including plating, Luque wiring, lumbosacral pedicle screws, and lumbopelvic constructs. Schiffhauer et al. published the only study on patients treated with a specific stabilization method using lumbopelvic stabilization. In that report of 19 consecutive patients, the fixation usually started at L-4 and a laminectomy was performed, as all patients presented with some neurological deficit.

Faced with such inherent instability of the fracture and in the absence of any neurological deficit, we tend to stabilize the fracture surgically to better control the outcome. Further justification for reducing the anterior translation is the restoration of normal biomechanics to reduce the risk of nonunion and hopefully the resultant chronic pain as well as to prevent the skin breakdown resulting from tethering and dimpling of the skin as a result of severe anterior translation. The evolution of spinal instrumentation has offered us tools to deal with such a demanding procedure. First, pedicle screws have given us the opportunity to apply 3D corrective forces in a relatively controlled manner. Reduction screws in conjunction with the persuaders have made gradual reduction with an even distribution of the corrective forces feasible to avoid screw pullout or pedicle fracture and/or failure. However, in cases in which it happens, a rescue procedure could involve a second attempt at reduction from the opposite side. And, if that fails, we could perform in situ stabilization with an extended laminectomy to ensure that the spinal canal is not compressed.

This procedure carries the standard risks of a common lumbo-iliac posterior instrumentation. Additional risks include dural impingement and/or nerve root entrapment during the reduction, major vascular injury, and of course failure of the reduction maneuver. Intraoperative neuromonitoring is a well-established methodology for the early detection of neurological deficits resulting from the surgical intervention; it can be performed by spinal surgeons with high sensitivity and specificity but also with certain limitations that are beyond the scope of this paper. The value of a wake-up test remains unequivocal, especially in the setting of a hospital lacking the luxury of intraoperative neuromonitoring. While the depth of anesthesia and the residual muscle relaxation can put a negative response in doubt, a positive response is always true and beyond doubt. In our case, the structures at risk—mainly during the reduction maneuver—included the L-4 to S-4 nerve roots. A true positive result would mandate reversal of the reduction and reassessment. In cases signaling improvement, a further less aggressive trial could be attempted after an extensive L5–S1 laminectomy to reduce the risk of nerve root impingement. In situ stabilization without full restoration of sagittal alignment is the solution in cases in which neuromonitoring remains problematic. Nevertheless, S-2 to S-4 nerve roots are difficult, if not impossible, to assess even with aggressive neuromonitoring methods.

Conclusions

In summary, we believe that this new technique of open reduction and posterior instrumentation of Type 3 high transverse sacral fracture-dislocations is a technically feasible, although demanding, procedure with certain indications and limitations. Undoubtedly, it carries additional risks compared with those for a simple in situ stabilization, but it also grants biomechanical advantages that need to be proved in a long-term follow-up.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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Address correspondence to: Konstantinos A. Starantzis, M.D., Nottingham University Hospital, Centre for Spinal Studies and Surgery, D Floor, West Block, Queens Medical Centre, Derby Rd., Nottingham NG7 2UH, United Kingdom. email: kstarant@hotmail.com.