Posterior Approach in Treating Sacral Fracture Combined With Lumbopelvic Dissociation

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abstract

Type III Denis fracture of the sacrum is rare clinically, constituting approximately 16% of all sacral fractures. Because it is often complicated with neurologic injuries, treatment is crucial and difficult. Several surgical options are available for the treatment of type III Denis sacral fracture with lumbopelvic dissociation. The authors report 21 patients admitted to the hospital from February 2002 to May 2012 who had type III Denis sacral fracture combined with lumbopelvic dissociation. All of the patients were treated with posterior sacral lamina decompression, sacral nerve root decompression, fracture reduction, an integrated lumbopelvic internal fixation system, and posterolateral fusion. The authors recorded pre- and postoperative complications, fracture reduction, bone graft healing, and improvements in neurologic function, according to the Gibbons grading standard. The average surgical time was 190 minutes (range, 170-210), and the average amount of intraoperative bleeding was 960 mL (range, 930-1500). No intraoperative complications occurred. Twelve patients had complete recovery of neurologic function; 5 patients showed great improvement except for foot drop and impaired lower limb sensation; and 4 patients showed no improvement in lower limb, bladder, and rectum function. Gibbons grade decreased from an average of 3.43±0.51 before surgery to 1.76±1.09 at the last follow-up. Deep infections were noted in 2 cases, and in 1 case, vertebral screw loosening was observed 1 year postoperatively. Surgical reduction with lumbopelvic fixation is an ideal method for treating type III Denis sacral fracture with neurologic injury and lumbopelvic dissociation.

Figure: A 28-year-old man with a fall injury showing type III Denis fracture with lumbopelvic dissociation. Lateral computed tomography scan of the sacrum (A). Anteroposterior 3-dimensional computed tomography scan of the sacrum after the injury showing the fracture line between S1 and S2, with S1 shifting forward and involving area III (B). Anteroposterior radiograph of the sacrum after posterior decompression and lumboiliac fixation (C). Lateral radiograph of the sacrum showing that the anatomic order of the spine was restored (D). After 18 months, lateral computed tomography scan of the sacrum showing bony fusion of the S1 and S2 fracture line in the sagittal plane (E). Anteroposterior 3-dimensional computed tomography scan of the sacrum. In the coronal plane, bony bridge formation was observed at the bilateral posterolateral graft bones (F).

Type III Denis fracture of the sacrum, the hinge connecting the spine and the pelvis, is rare clinically, accounting for approximately 16% of all sacral fractures.[1] It is associated with a high incidence of neurologic injury (up to 60%).[2] An H- or U-shaped type III Denis comminuted sacral fracture with lumbosacral dislocation, a rare injury and an unstable fracture that is also referred to as spondylopelvic dissociation,[3] may cause spine and pelvic instability. Clinical treatment of type III Denis sacral fracture with lumbopelvic dissociation is difficult. Between February 2002 and May 2012, 76 patients were admitted to the authors' hospital with sacral fracture. Of these patients, 21 (27.6%) had type III Denis sacral fracture with lumbopelvic dissociation. The authors retrospectively analyzed clinical data for the 21 patients to evaluate the surgical method. This article reports the authors' experience with treating these patients with type III Denis sacral fracture with lumbopelvic dissociation.

MATERIALS AND METHODS

This study included 21 cases, 13 male and 8 female patients, with an average age of 34.6 years (range, 17-56). Patients experienced a fall in 13 cases, traffic trauma in 6 cases, and crush-related injury in 2 cases. According to the Gibbons grading standard,[2] 12 cases were classified as grade 3, 9 cases were classified as grade 4, and 11 cases involved multiple injuries. All patients showed obvious signs of sacral nerve root injury, including pain in the posterior thigh, posterolateral lower leg, and heel; reduced superficial sensation in corresponding areas; decreased muscle strength of the triceps surae; and absence of the tendo calcaneus reflex. Nine patients had renal retention and sensory disturbances of the sellar area. Preoperative examination included radiographic plain films, 3-dimensional computed tomography (CT) reconstruction, and magnetic resonance imaging (MRI) scans in-

dicating lumbopelvic dissociation, sacral fracture, and sacral canal deformity and narrowing in all cases, consistent with type III Denis fracture. According to the Roy-Camille classification,[4] of the 21 cases, 9 were type II and 12 were type III. The fracture lines were at or above S2 in 12 cases and below S2 in 9 cases. The authors excluded patients with longitudinal type III Denis sacral fracture, severe pelvis anterior ring injury, and severe osteoporosis. The **Table** shows details of the injuries.

Preoperative Preparations

Patients experiencing shock received treatment, and combined injuries were initially treated. After the vital signs were stabilized, CT scan, 3-dimensional CT reconstruction, and MRI scan were obtained to determine bone chip displacement and the status of neurologic injuries. Sacral fracture surgery was performed within an average of 7 days after injury.

Surgical Procedure

After general anesthesia was administered, the patient was placed in the prone position. With a posterior midline incision, the bilateral vertebral plates and posterior superior iliac crests were exposed. Spinal canal and spinal aperture exploration and decompression were performed, followed by clearing of hematomas and bone chips, cutting down of the sacrum vertebral plate of the fracture area, and decompression of the sacral canal.[5] Based on the surgical findings, the authors identified 17 patients with sacral nerve root adhesion and traction, 3 with unilateral nerve root damage, and 1 with bilateral nerve root damage. Pedicle screws were placed bilaterally between L3 and L4. At the level of the posterior superior iliac crest, screws were placed bilaterally into the sacrum. After the connecting rods were preflexed and installed, fracture reduction was achieved through prying, pulling, and lifting. Posterolateral fusion was eventually performed.

Postoperative Treatment and Assessment Criteria

The drainage tube was removed 48 to 72 hours postoperatively. Conventional treatment with broad-spectrum antibiotics was provided for 3 days after surgery. Patients with partially conserved neurologic function were given short-term, low-dose glucocorticoid treatment. Patients without contraindications were encouraged to engage in early in-bed functional training. Off-bed activity was recommended 8 to 12 weeks after surgery.

Radiographic plain films of all patients were obtained 6 weeks, 12 weeks, 6 months, and 1 year postoperatively. The authors recorded recovery of neurologic function, fracture healing, and complications. Fracture healing was assessed based on CT scans obtained 12 weeks postoperatively. Recovery of neurologic function was evaluated with Gibbons standardized grading[2] as follows: 1=complete recovery of nerve function; 2=simple decline of sensation in the lower limbs; 3=obstacle to lower limb activity; and 4=bladder and rectum dysfunction. Complications in the preoperative period, diaplasis during and after surgery, vertebral fusion, and internal fixation were recorded.

RESULTS

Surgery lasted 170 to 210 minutes, with an average of 190 minutes. Intraoperative bleeding was 930 to 1500 mL, with an average of 960 mL. No intraoperative complications were observed. Postoperative radiographic films and CT scans indicated sufficient decompression in the spinal canal, good internal fixation, and satisfactory fracture reduction. Two patients had early postoperative culture-proven *Staphylococcus aureus* infection and were treated with prompt debridement and irrigation with appropriate antibiotics. Follow-up visits were scheduled for all patients at 8 to 36 months, with an average of 20 months. Seven months postoperatively, radiographic plain films and CT scans were evaluated, suggesting fracture healing and

	Table					
	Clinical Data					
Case No./ Sex/Age, y	Cause of Injury	Classification	Fracture Location	Gibbons Grade Pre-/Postoperatively	Combined Injuries	Follow-up, mo
1/M/28	Fall	H	S1-S2	4/2	Calcaneal fracture	9
2/F/31	Traffic	H	S2-S3	3/2	None	8
3/M/27	Crush	H	S3-S4	4/4	Brain trauma	24
4/M/46	Traffic	T	S1-S2	3/1	None	21
5/F/23	Fall	H	S2-S3	3/1	L3 fracture	18
6/M/24	Fall	T	S1-S2	4/1	Pneumohemothorax	19
7/M/36	Fall	H	S1-S2	4/2	Pneumohemothorax	22
8/F/19	Fall	H	S2-S3	3/1	None	33
9/M/22	Traffic	T	S3-S4	3/1	Right humeral fracture	16
10/F/25	Traffic	T	S2-S3	3/1	Rib fracture	17
11/F/21	Crush	U	S1-S2	4/2	None	12
12/M/35	Fall	T	S3-S4	3/1	None	22
13/M/29	Fall	T	S3-S4	3/2	L5 fracture	12
14/F/43	Traffic	U	S2-S3	4/1	Rib fracture	31
15/M/32	Fall	H	S1-S2	4/1	None	36
16/M/17	Fall	H	S1-S2	3/1	None	11
17/F/31	Fall	U	S3-S4	4/4	None	25
18/M/24	Fall	T	S2-S3	3/3	None	33
19/F/40	Traffic	H	S1-S2	3/1	Pneumohemothorax	16
20/M/34	Fall	U	S2-S3	3/1	None	16
21/M/56	Traffic	H	S1-S2	4/4	Clavicle fracture	24

Abbreviations: F, female; M, male.

vertebral fusion with no obvious pelvic deformity or pseudarthrosis (**Figure**). Complete recovery of neurologic function occurred in 12 cases. Great improvement in neurologic function was observed in 5 cases, with foot drop or impaired sensation of the lower limbs. Slight or no improvement was observed in 4 cases, with lower limb dysfunction and impaired bladder and rectum function. Gibbons grade decreased from an average of 3.43±0.51 before surgery to 1.76±1.09 at the last follow-up. After surgery, 2 patients had skin flap necrosis. One patient had S1 vertebra screw loosening 1 year postoperatively, possibly caused by the concentration of stress in the lumbosacral area.
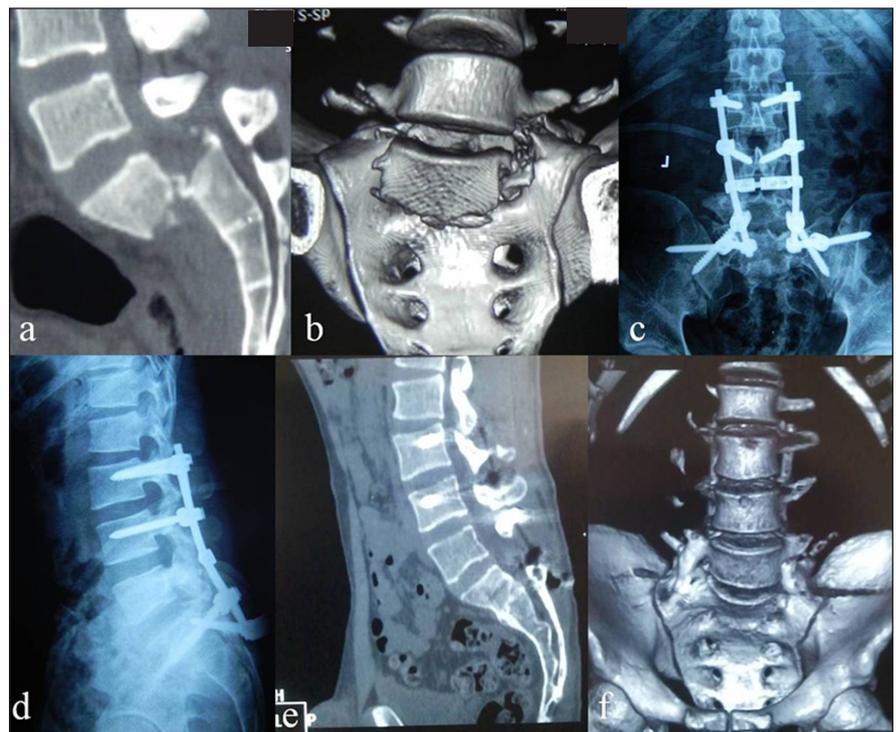
DISCUSSION

Sacral fracture with lumbopelvic dissociation is usually caused by high-energy trauma.[6] The most common mechanism is a jump or fall from height.[7] In the current report, 61.9% (13 of 21) of fractures resulted from a fall, similar to the 67.3% reported by König et al.[7] Falls often cause other severe injuries, ranging from calcaneal fracture to severe thoracic-abdominal injury or limb fracture.[8,9] The therapeutic window for treating sacral fracture with lumbopelvic dissociation is within 48 hours of injury to 2 weeks after injury, and a delay in surgery is not conductive to complete recovery of neurologic function.[1,10] However, Yi and Hak[11] found that stabilizing the pelvic ring within 72 hours could enhance the survival rate and reduce complications. For a patient with sacral fracture and lumbopelvic dissociation, rescue usually involves general surgery and neurosurgery, which may delay diagnosis and treatment. The sacrum is a spongy bone that has a rich blood supply and heals quickly, and without early treatment, malunion can further compress the nerve roots, leading to deteriorating neurologic symptoms and eventually affecting recovery.[1,8,10] Once radiographic plain films show sacral fracture combined with lumbopelvic dissociation, CT scan is recommended for further diagnosis and therapeutic planning.[12,13] Because of the

special attention paid to early diagnosis of sacral fractures with radiographic films and CT scans as well as early surgery (average, 7 days) in the current 21 cases, satisfactory results were achieved.

Unstable sacral fractures can easily combine with nerve impairment, and in this case, internal fixation is needed to restore the stability of the pelvic ring and protect the injured lumbosacral nerve root.[14,15] Proper reduction and internal fixation for an unstable sacrum could reduce osteotylus formation and prevent nerve injury caused by osteotylus or fibrosis.[5,16] Patients with sacral fracture and nerve injury should undergo nerve exploration and decompression relief of the fracture fragments on the lumbosacral nerve root. With surgery, neurologic improvement has been reported to increase to 80%.[5,17] In the authors' 21 cases of sciatic nerve injury, intraoperative exploration showed that the fracture fragments had compressed the sacral nerve root. After reduction and relief of compression, 12 patients (57.1%) achieved complete recovery, 5 patients (23.8%) showed good improvement except for foot drop or impaired sensation of the lower limbs, and 4 patients (19.0%) had sacral nerve root transections that were later treated with peripheral nerve sheath sutures, with no improvement in lower limb, bladder, and rectum function. In this case, special attention must be paid to surgical decompression to promote recovery of nerve injury.

All patients in the current study had type III Denis sacral fracture combined with lumbopelvic dissociation and weak stability. Regular iliosacral screw fixation[12,18] could not meet the need for reduction and decompression, so the authors turned to spinopelvic fixation.[5,16,19] First, the lumbar pedicle screw and the sacrum screw were connected by a bent rod that was applied bilaterally. Second, a transverse connector was placed between the rods to prevent postoperative shift (**Figure**). This procedure provided satisfactory results not only in longitudinal, transverse, U-shaped, and H-shaped

Figure: A 28-year-old man with a fall injury showing type III Denis fracture with lumbopelvic dissociation. Lateral computed tomography scan of the sacrum (A). Anteroposterior 3-dimensional computed tomography scan of the sacrum after the injury showing the fracture line between S1 and S2, with S1 shifting forward and involving area III (B). Anteroposterior radiograph of the sacrum after posterior decompression and lumboiliac fixation (C). Lateral radiograph of the sacrum showing that the anatomic order of the spine was restored (D). After 18 months, lateral computed tomography scan of the sacrum showing bony fusion of the S1 and S2 fracture line in the sagittal plane (E). Anteroposterior 3-dimensional computed tomography scan of the sacrum. In the coronal plane, bony bridge formation was observed at the bilateral posterolateral graft bones (F).

sacral fractures but also in displaced sacral fractures.[13] Adequate reduction was achieved in all patients in the current study, and the fractures showed osteal healing 10 to 12 months postoperatively, with no postoperative displacement. The procedure offered good biologic properties and balanced the abnormal stress of the pelvic posterior ring.[19] It also played an important role in reduction and fixation. Furthermore, the transverse process and posterolateral bone graft fusion were crucial because late-stage bone fusion can greatly affect fracture healing.

Before the 1960s, fixation in situ and long-term bed rest with gypsum were the conventional methods for reconstruction of lumbar and sacral spine stability,[20] but they were associated with a high incidence of pseudarthrosis (up to 50%). With the development of surgical techniques such as the Harrington-Luque and Cotrel-Dubousset methods in spine surgery, the spine fusion rate improved. However, drawbacks included smooth back deformity, nerve injury, and extrusion of instruments. With the rapid development of internal fixation, more instruments have been used in reconstruction of lumbar and sacral spine instability caused by sacral fracture, such as lumboiliac plates,[4] transiliac plates,[21] transiliac rods,[22] and percutaneous iliosacral screws.[12,23,24] Each has merits as well as drawbacks, including hard molding, weak stability, and limited indications.

No consensus has been reached on the most suitable method for internal fixation

of sacrum fracture. The lumbopelvic internal fixation system (Medtronic, Inc, Minneapolis, Minnesota) can achieve lumbar and sacral fixation and spinal fusion and greatly enhance the fusion rate. A screw is placed between the inner and outer sacral lamellae and connected to the lower lumbar pedicle screw with a connecting rod. In this way, the procedure is simplified and the tensile strength of the sacral screw on the sagittal plane is improved, increasing the stability of internal fixation. Biomechanical experiments have shown that pullout strength is greater when the screw is placed between the inner and outer sacral lamellae, and this procedure provides strength that is approximately 3 times greater than that achieved with the general Galveston technique.[25] In addition, after application of the lumbopelvic internal fixation system, all of the loading would be delivered to the pelvis by the connecting rod at an early stage of spinal load bearing, thus eliminating sacral load bearing and facilitating fracture healing. For this reason, the lumbopelvic internal fixation system is more efficient than other internal fixation methods for the lumbar and sacral spine. This system also offers the benefits of simple operation, enhanced fixation strength, and improved stability. Therefore, the lumbopelvic internal fixation system is a safe and effective method for the treatment of severe sacral fracture-dislocation.

Complications of lumbopelvic fixation primarily are wound healing disturbances and rod breakage,[14] and the overall wound healing complication rate is 26% to 50%.[10,14] Because of the thin soft tissue of the sacrococcygeal region, sacral fracture can cause sacral nerve compression. Furthermore, sacral decompression inevitably disrupts the blood supply of the surrounding soft tissue, which would also be compressed by the connecting rod with the big radius protruding posteriorly. Because of the associated problems, the authors preserve L5 paraspinal muscles as much as

possible and use high-fixation pedicle screws to avoid compression, thus reducing the incidence of infection to 9.5%. In 1 case, a radiograph obtained 1 year after surgery showed loosening of the screws. Because the patient had no symptoms, no treatment was offered.

Many surgeons prefer to place the pedicle screws at L4 or L5 and S1 during iliolumbar fixation.[5,16] Because the plane of the sacrum screw is higher than that of the pedicle screw, the fixed link must be bent into an S-shape so that it can connect with the screws. The authors preferred to use L3 and L4 to reduce the slope between the pedicle screw and the sacrum screw so that the slight bend of the fixed link would prevent damage. In addition, because the patients in the study were underweight, weight bearing began early after surgery and the internal fixation was removed after fracture healing, reducing the incidence of fixed link break. However, there are still some concerns about this procedure. Specifically, a bone groove at the posterior superior iliac crest may reduce protrusion of the screw but may also affect pullout strength. Whether equal biomechanical stability could be achieved if the screw is placed between L5 and L4 remains to be investigated. To solve these problems, biomechanical tests and a larger sample size are needed.

CONCLUSION

Although clinical treatment of type III Denis sacral fracture with lumbopelvic dissociation is challenging, the authors suggest that posterior surgical reduction and lumbopelvic fixation would be an ideal treatment method.

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