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Isolated Decompression for Transverse Sacral Fractures with Cauda Equina Syndrome

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Background: The purpose of this study was to evaluate the clinical outcomes of isolated decompression for patients with transverse sacral fractures and cauda equina syndrome, which have been rarely reported before.

Material/Methods: Twelve neurological impaired patients with transverse sacral fracture from January 2010 to March 2017 treated in our institution were evaluated. All patients went through isolated decompression and were followed for a minimum of 12 months. Fracture causes, classifications, associated injury, radiologic results, clinical outcomes using the Majeed index, and neurological outcomes using the Gibbons criteria were evaluated.


Results: Motor vehicle accidents and falling injuries were the major causes of trauma. The average time from trauma to surgery was 89.8 days. Eleven patients underwent laminectomy with no more than 3 segments resected and 1 patient had S1-S4 excised. Three patients with fracture involving the lumbopelvic joint had L5 laminectomy. All patients achieved bony union, with 7 patients (63.6%) showing satisfactory pelvic outcome. Average Gibbons scores improved from 2.8 to 1.9 at 18-month average follow-up, but most patients were left with residual pain. No surgical-related complications were seen in any patients.

Conclusions: Isolated decompression can be considered for patients who present a stable sacrum with non-displaced fracture or an old fracture that shows fracture healing. Favorable pelvic outcomes and neurological recovery, along with acceptable stability, can be acquired.

MeSH Keywords: **Decompression, Surgical • Fracture Healing • Polyradiculopathy**

Abbreviations: **CT** – computed tomography; **VAS** – visual analogue scale; **APC** – anterior-posterior compression; **VS** – vertical shear; **LC** – lateral compression; **MVA** – motor vehicle accident; **ED** – erectile dysfunction

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Background

Sacral fractures often result from high-energy trauma and are associated with pelvic ring instability. Longitudinal and transverse fractures, involving the foraminal region and central canal, often lead to lumbosacral plexus injuries and cauda equina deficits. A previous review of 90 patients with traumatic transverse sacral fractures revealed 97% with neurological damage [1]. The commonly reported impairments involve motor and sensory function, as well as paralysis of bladder and bowel functions, which severely diminish patient quality of life.

The outcomes of using internal fixation techniques with or without laminectomy for treatment of sacral fracture patients with nerve deficits to relieve entrapment of the nerve root and restore the stability of pelvic ring and spinopelvic junction have been widely reported before [1–13]. However, the prognosis of isolated sacral canal decompression without any stabilization instrumentation for sacral fractures with neurological impairments remains unclear. Considering the importance of the sacrum to maintain pelvic stability and weight bearing, it is rarely used without fixation technique. Although rare, favorable neurologic results were reported from previous cases [14–20]. In our department, this kind of surgery is only considered when encountered in patients with stabilized fracture pattern or old fracture with obvious callus formation.

The aim of this retrospective study was to evaluate isolated decompression without any internal fixation of the pelvic posterior ring as a treatment method for sacral fractures with cauda equina syndrome by assessment of neurologic and pelvic function recovery.

Material and Methods

In this observational study, we reviewed all sacral fracture patients treated at Shandong Provincial Hospital Affiliated to Shandong University, a level 1 trauma center, in Jinan, Shandong, China, from January 2010 to March 2017, and identified 12 patients with cauda equina syndrome treated with decompression and without internal fixations of the pelvic posterior ring who met the inclusion criteria, and these 12 patients were enrolled in the study. This study was approved by the Medical Ethical Committee of Shandong Provincial Hospital Affiliated to Shandong University, and written informed consent was obtained from all participants. Patient data were obtained from hospital records. X-ray and computed tomography (CT) scanning were used to delineate the fracture pattern of the sacrum and pelvic ring. Sacral fractures were classified using the criteria by Denis [21], Roy-Camill [22], and Strange-Vognsen [23]. Pelvic injuries were categorized according to Young-Burgess classification [24]. Follow-up was routinely

scheduled every 3 months within the first year postoperatively, and annually thereafter. Angulation displacements across the fracture site were documented using the methods established by Kuklo et al. [25]. The clinical outcomes were evaluated at final follow-up using the Majeed score [26]. Neurologic deficits were classified according to Gibbons et al. [27]. Pain was evaluated according to visual analogue scale (VAS).

Results

Patient characteristics

Preoperative clinical data, including demographic information, mechanism of injury, associated injuries, and types of pelvic fractures, of 12 patients who met the inclusion criteria are listed in Table 1.

There were 12 patients, including 6 males and 6 females, with an average age of 35.4 years (range, 14–62 years). Mechanisms of injury in these patients included motor vehicle accident (MVA) (5 patients), falling (5 patients), and crushing injury (1 patient). Since some patients were transferred from other medical institutions, accurate evaluation of severity of injury at admission could not be assessed. These patients' associated injuries were recorded according to prior medical history. Vertebral fracture was the most common associated injury, and 1 patient underwent right lower limb amputation at a local hospital because of destructive injury.

The type of pelvic fracture was classified using Young-Burgess classification. Four patients sustained anterior-posterior compression (APC) injuries related to MVA, 6 patients sustained vertical shear (VS) injuries (all due to falling injuries) and 2 sustained lateral compression (LC) injuries. Nine patients also had disruption of the anterior ring.

Sacral fracture pattern and surgical treatment

The sacrum fracture patterns are shown in Table 2. All patients had transverse sacral fractures (Dennis zone III type) involving the sacral canal. Three patients had transverse fractures in more than 1 place. The location of transverse fractures was mainly above the S3 level.

Decompression of neural elements was accomplished by sacral laminectomy through a posterior midline incision. The extents of laminectomy are listed in Table 2.

All patients had more than 1 segment excised – 8 patients with 2 segments excised, 3 patients with 3 segments excised, and 1 patient with S1-S4 excised. Three patients with fractures involving the lumbosacral joint also had partial L5 excised (Figure 1).

Table 1. Patients' characteristics and pelvic fracture pattern.

Patient no.	Age	Sex	Mechanism of injury	Associated Injury	Pelvic fracture type	Disruption of the anterior pelvic ring	Days from trauma to surgery
1	14	Female	Fall	Bilateral tibial and fibular fracture Left calcaneal fracture	VS	No	30
2	30	Female	Fall	L3–L5 transverse process fracture	VS	Yes	7
3	14	Female	Fall	T7–T11 fracture Bilateral calcaneal fracture	VS	Yes	26
4	15	Female	Fall	L1 fracture Right femoral neck fracture Left tibial and fibular fracture Bilateral calcaneal fracture Pneumothorax	VS	Yes	34
5	49	Male	Fall	None	VS	Yes	36
6	50	Male	Fall	L5 fracture left Femoral fracture	VS	No	80
7	29	Male	MVA	None	APC	Yes	29
8	53	Female	MVA	None	APC	Yes	40
9	62	Male	MVA	Renal injury, Left Metatarsal fracture	APC	Yes	81
10	24	Female	MVA	Shock Urinary injury Vaginal injury L5 transverse process fracture Retroperitoneal hematoma Pulmonary injury	APC	Yes	47
11	49	Male	MVA	None	LC	No	542
12	36	Male	Crush	Right lower limb destructive injury (Amputation in local hospital)	LC	Yes	130

MVA – motor vehicle accident; APC – anterior-posterior compression; LC – lateral compression; VS – vertical shear.

All but the amputated patient had total laminectomy. Internal fixations were used to fix the fractured pubic ramus or separated pubic symphysis in 7 of 9 patients who presented with disruption of the anterior pelvic ring. The average time from trauma to surgery was 89.8 days (range, 7–542 days). The average operation time was 144.6 min (range, 110–180 min) and the mean intraoperative bleeding volume was 337.5 ml (range, 200–700 ml).

Outcome evaluation

The mean postoperative follow-up time was 18 months (range, 13–28 months) and pelvic functional outcome was assessed at final follow-up according to Majeed scoring system: excellent (>85 points), good (70–84 points), fair (55–69 points), and poor (<55 points) [26]. The patient with right leg amputation was excluded. Three young female patients without sexual

experience but with normal menstruation and normal urethral function were considered normal sexual function and graded 4 points in sexual intercourse. The mean score was 76 points (range, 53–96 points), which were graded as follows: 2, excellent; 5, good; 3, fair; and 1, poor.

The neurological impairment was graded using Gibbons classification [27]. Based on this criterion, type 1 indicates normal neurological function, type 2 indicates sensory deficits only, type 3 indicates abnormal motor function, and type 4 indicates bowel and/or bladder dysfunction. Neurological outcomes are listed in Table 3. The average score improved from 2.8 to 1.9. Only 4 patients gained full neurological recovery. Seven patients still had paresthesia. Three patients showed no improvement according to Gibbons scale and 1 patient still had urination and defecation troubles at last follow-up.

Table 2. Sacral fracture pattern and decompression extent.

Patient no.	Sacral fractures			Segments of laminectomy
	Dannis	Roy-Camille and Strange-Vognsen	Level of transverse fracture	
12	III	4 3	S1 S3-S4	L5-S1
11	III	2	S1-S2	L5-S1
5	III	4	S1-S2	S1-S2
6	III	4 2	S1-S2 S3-S4	L5-S2
9	III	3	S1-S2	S1-S2
10	III	3	S1-S2	S1-S2
4	III	4 2	S1-S2 S3	S1-S4
1	III	2	S2	S1-S2
2	III	2	S2	S1-S3
8	III	2	S2	S1-S2
3	III	3	S2-3	S1-S3
7	III	2	S3	S2-S3

Pain was assessed using a visual analogue scale (VAS), ranging from 0 to 10, with 0 representing no pain and 10 the most severe pain (Table 3). Only the pain possibly related to the neural injury was evaluated, including pain in the lower back and pelvic region, and radicular pain to the lower extremities. The average VAS score was 2.2 (range, 0–6) and 1 patient complained of remaining radicular pain at last follow-up.

Two patients complained of pain in sexual intercourse and one of them also complained of erectile dysfunction (ED). No sexual dysfunction was noted in the other patients (Table 3).

Discussion

Transverse sacral fractures are often caused by high-energy trauma and are associated with high prevalence of neurological injury. Whether conservative or surgical intervention should be used is still controversial. A recent paper reviewed 521 traumatic transverse sacral fracture patients and concluded there was no improved neurological recovery after surgical treatment compared with nonoperative treatment [28]. As this kind of injury is often associated with spinopelvic dislocation, lumbosacral fixation for transverse sacral fractures has been increasingly used to reconstruct lumbosacral stability in recent years [5–10,12,29,30]. Because indirect decompression can be achieved through realignment of displaced fractures,

there is debate about whether direct decompression is needed. Although no better neurologic or pelvic outcomes were reported in cases of direct decompression compared with indirect decompressed patients [6,31], this conclusion may result from nerve root injury caused by bony encroachment in the sacral canal and dural tears seen in the operation [6]. Based on our experience, laminectomy and wide decompression were best when patients showed signs of neurologic deficits and radiographic evidence of spinal canal encroachment [8]. MRI results showed that after relieving displaced fragments, the compressed nerve root presented more clear morphology and the patient showed obvious neurologic recovery (Figure 2).

Previous reports of isolated decompression used for sacral fractures were primarily derived from case reports [14–18,20]. To the best of our knowledge, the present study contains the most cases, with 12 patients, published thus far. Previous reports showed neurological improvement in patients with stable fractures and treated with isolated decompression [14,16,18,20]. No postoperative complications occurred in these patients. Also obsolete fracture was considered as an important indication [15,16,19]. Mahajan concluded that decompression alone could be considered for patients with old fractures for more than 6 weeks and when the fractures showed no gross displacement [16]. For our patients, preoperative decision was made basically the same as in the previous report. Stability of the pelvis was our most important concern. Patient 2

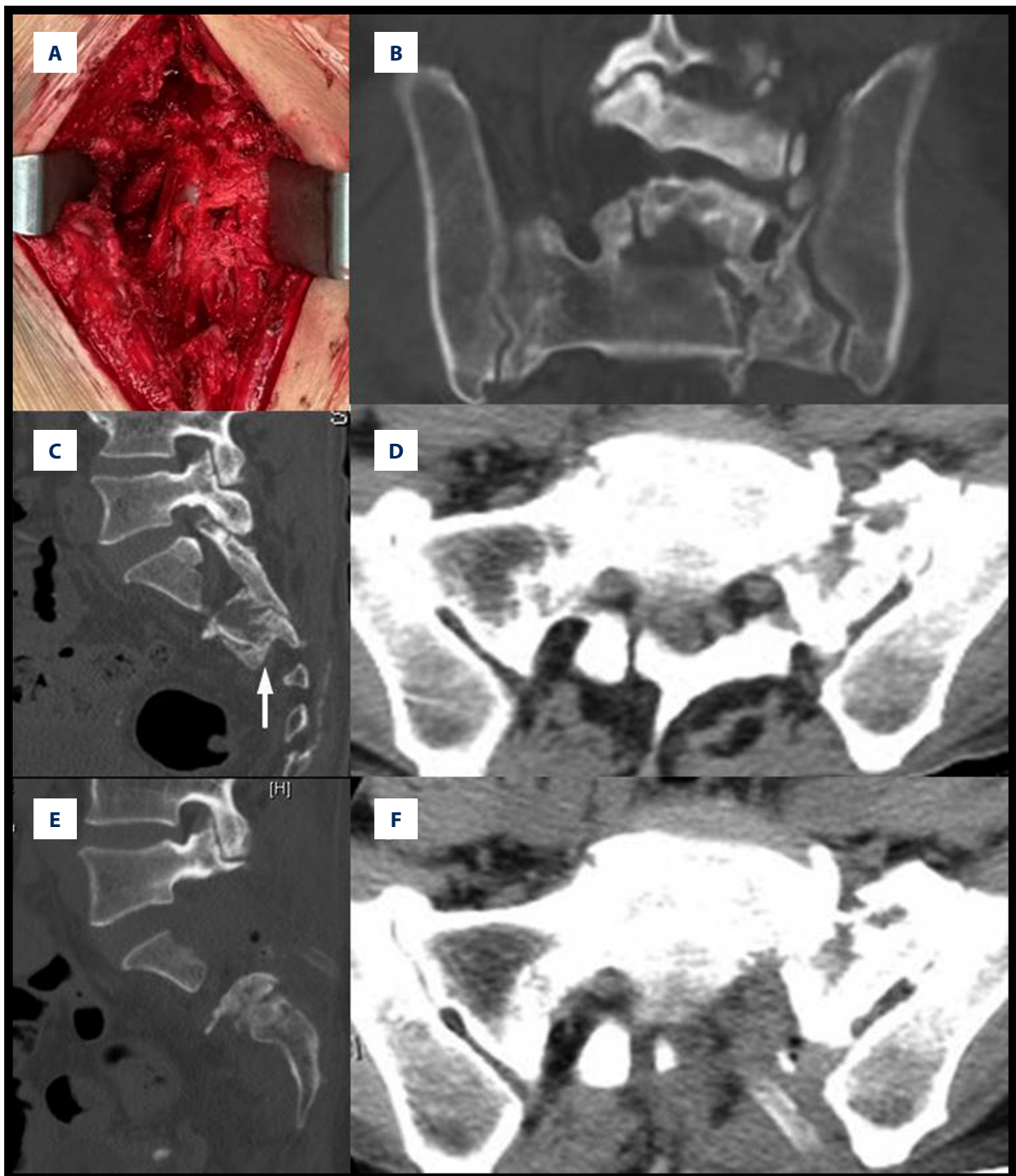


Figure 1. A 50-year-old male (patient 6). Exposure of compressed L5 and S1 nerve root during the surgery (A). Preoperative CT image, coronal view (B), sagittal view (C) with arrow shows callus formation before the surgery, and axial view (D). Postoperative CT image shows L5-S2 laminectomy, sagittal view (E), axial view (F) (L – left, R – right).

underwent the surgery within 1 week after the injury, with the fracture showing no displacement. Excluding that patient, the length of time from injury to surgery of the other patients was more than 25 days, and fracture healing could be seen from

the image. For patients with an old fracture, the fracture is healing and relative sticky. The surgical strategy was decided on with the goal that the pelvis would be relatively stable after the surgery. However, most patients in previous reports

Table 3. Neurological outcome.

Patient no.	Preoperative Gibbons score	Postoperative Gibbons score	VAS	Sexual function
11	2	1	2	Normal
1	3	2	0	Normal
7	4	4	3	Pain+ED
2	2	1	0	Normal
12	2	1	2	Normal
3	3	3	1	Normal
4	3	1	3	Normal
6	3	2	2	Normal
8	3	2	2	Pain
9	3	2	5	Normal
5	2	2	6	Normal
10	4	2	0	Normal

ED – erectile dysfunction.

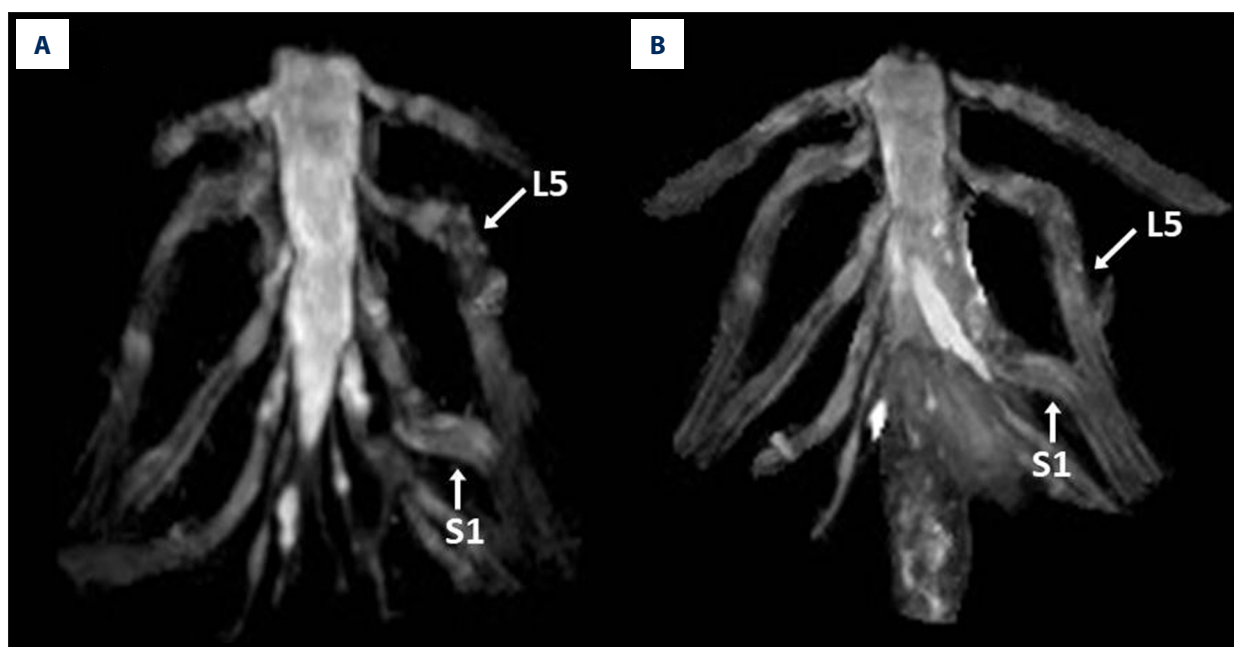


Figure 2. Three-dimensional nerve magnetic resonance reconstruction from a forward view, and a postoperative image (B) shows clearer morphology of L5 and S1 nerve roots after decompression compared with a preoperative image (A).

had a fracture line below S2 level. Fixation is usually favorable in high-region sacral fractures because it is important in the transmission of weight from the lower extremities to the spine [32]. In this case series, 7 patients had fractures at S1 level. Our experiences show that a favorable outcome can be acquired even in patients with high-region sacral fractures. Above all, we think that a stable pelvis can be anticipated after decompression alone for fracture patients with a relatively stable sacrum, including non-displaced fractures and old fractures that show fracture healing.

Zelle et al. [2] and Ayoub [4] et al. reported better neurological recovery may be achieved with early decompression. Although prolonged delay may negatively influence neurological recovery [21], most patients in this series had multiple injuries and the duration of surgery depended on their physiologic status. Three patients were transferred from local hospitals and their time to surgery was therefore random. Most patients had no more than 3 segments removed. Three patients with fractures involving the lumbosacral joint that had L5 lamina excised had been injured more than 80 days before the surgery, and clear callus

could be seen radiographically. Since no fixation technique was used for these patients, the stabilization was of particular concern. These patients had obvious delayed ambulation time, as compared with patients treated with stabilization instrumentation in our institute. Fortunately, no postoperative thrombosis formed in these patients. Seven of 11 patients (63.6%) showed satisfactory functional outcome (excellent and good). This ratio shows no significant difference compared to previously reported studies in which sacral fractures were treated by lumbopelvic fixation [6,8,9]. In our series, no patients needed walking aids except for the amputee patient. Slight limp gaits were seen in 3 patients, moderate limp in 1 patient, and gross limp in 1 patient. The patients with L5 laminectomy showed good pelvic outcome at the last follow-up, and returned to work, with the exception of the amputee patient.

In previous studies, an increase of kyphosis was seen at postoperative follow-up in both operative and conservative treatment [8,11]. Absence of fixation may lead to an increased risk of redisplacement of fracture ends. In the present series of cases, postoperative kyphosis angulation across the fracture site was measured following the Kuklo [25] criterion with an average of 25° (range, 10–56°) in 8 patients. Three patients with transverse fractures at 2 different levels but showing undisplaced fracture at the upper sacrum were not taken into consideration. No obvious change was seen at the follow-up visit, which can be attributed to old fractures and delayed weight-bearing time. The angulation displacement has been reported as a prognosis factor of neurologic recovery and pelvic outcome [6,9,29]. No such correlation could be seen in this series of patients, given the small sample size.

According to the anatomical research by Denis [21], the upper sacral diameter ratio of nerve root to foramen was significant higher than in the lower sacrum, which can partially explain the higher prevalence of S1–S2 nerve root injury in this case series. Statistically, high sacral fractures above S3 were more favored by operative treatment [28].

Improved neurological recovery, as assessed using the Gibbons scale, was seen in most patients postoperatively, from a mean of 2.8 to 1.9. Four patients gained full neurological recovery and 3 patients showed no improvement. Of these 3 patients (patients 3, 5, 7), 1 patient (patient 7) complained of difficult urination and defecation at the last follow-up, and he showed severe neurologic deficits on admission. Although the fracture only involved the lower sacrum, displaced fragments showed obvious encroachment into the sacral canal and presented nerve evulsion in surgery. Another patient (patient 5) also showed nerve evulsion during the surgery, and the last one (patient 3) had multiple thoracic vertebral fractures, which may partly account for the neurologic deficits. It is likely that the transection, evulsion, contusion, and traction

may be related to poor neurologic prognosis, which is consistent with other scholars [3,6,29]. Two patients complained of limited sexual function, making the ratio much lower in than previous reports [11,33]. This result may be attributed to the relatively better preoperative neurologic deficits of these patients than in previous reported cases. Pain is also an important factor that affects quality of life. Residual pain was seen in most patients at last follow-up, and similar results were found in other reports [11,12]. One patient with persistent pain and intermittent radicular pain in the lower limb reported no improvement after surgery. Chronic pain after sacral fracture has been reported in many patients [11,28]. Adelved et al. [11] also noted that persisting pain may result from sacral kyphotic deformity, but found no relationship between kyphotic deformity and VAS. Denis et al. [21] reported that late painful deformities in patients received conservative treatment. These sequelae may be due to incomplete decompression and non-reduction of the fracture ends. Typically, displacement can be reduced by stabilization techniques. Previous reviews also reported a paucity of evidence that fixation of the fracture resulted in better neurological improvement as compared with isolated decompression [28]. While considering cases in this series were mostly obsolete fracture patients with callus formation at the end of fracture ends, which made reduction more difficult, and likely a higher risk of secondary stretched nerve, we chose to treat these patients without any implants in the posterior pelvic ring. However, it is acknowledged that more patients are necessary in order to do statistical analyses and produce convincing indications for isolated decompression treatment in sacral fracture patients with cauda equina injury.

No patients showed signs of nonunion radiographically, or postoperative wound infections. Given that no fixation instrument was used, the prominence of the implanted hardware was not a concern.

Conclusions

This study assessed a small case series of transverse sacral fractures with neurologic deficits treated with uncommon isolated decompression. We think isolated decompression can be considered for patients who present a stable sacrum with non-displaced fracture or an old fracture that shows fracture healing. Our experiences show that favorable pelvic outcomes and neurological recovery, along with acceptable stability, can be acquired. The absence of fixation techniques relieved patients of implant-related complications, but also lead to prolonged immobilization. The long-term outcomes remain uncertain.

Conflict of interest.

None.

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