Surgical treatment for suicidal jumper's fracture (unstable sacral fracture) with thoracolumbar burst fracture: a report of three cases

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Abstract:

Introduction: Suicidal jumper's fracture (unstable sacral fracture) is characterized not only by multiple fractures including thoracolumbar fractures, but also major chest and abdominal injuries. Early stabilization of these fractures and early ambulation are required for the treatment and management of chest and abdominal injuries. We present 3 cases of suicidal jumper's fracture with thoracolumbar burst fracture, treated with minimally invasive posterior fixation surgery, which is a combination of percutaneous pedicle screws (PPS) and the mini-open Galveston technique.

Case reports: Case 1. A 50-year-old woman was injured by a fall from the 5th floor of a building as the result of a suicide attempt. Computed tomography revealed an H-shaped unstable sacral fracture and thoracolumbar fractures with major chest and abdominal injuries. For early stabilization of spinopelvic instability and early ambulation, we treated the patient with PPS and the mini-open Galveston technique. Her early postoperative emergence from bedrest contributed to the improvement of her general condition. One year after surgery at the final follow-up, she was able to walk with a T-cane without any motor, bladder, or bowel dysfunction (BBD) and achieved almost complete healing of the fractures. Cases 2 and 3. A 25-year-old woman (Case 2) and a 43-year-old woman were injured in falls. They had multiple injuries including unstable sacral fractures, and thoracolumbar fractures with major chest and abdominal injuries. We treated these patients with PPS and the mini-open Galveston technique. One year after surgery, they were able to walk with a T-cane and achieved almost complete healing of thoracolumbar fractures, but delayed healing of an unstable sacral fracture in Case 2, and remaining BBD in Case 3.

Conclusion: PPS and the mini-open Galveston technique is a good approach to fixation because they are minimally invasive and provide moderately rigid fixation, especially in patients with multiple trauma whose general condition is poor.

Keywords:

Suicidal jumper's fracture, Thoracolumbar burst fracture, Unstable sacral fracture, Percutaneous pedicle screw

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Introduction

Roy-Camille et al. reported typical unstable sacral fractures such as U-type and H-type fractures, the results of falls from a height usually associated with suicide attempts by jumping, and so are called suicidal jumper's fracture[1)]. Suicidal jumper's fracture is often characterized not only by multiple fractures including thoracolumbar fractures, but also major chest and abdominal injuries. Early stabilization of these fractures, especially unstable sacral fractures and thoracolumbar burst fractures, and early ambulation are required for the treatment and management of chest and abdominal injuries. For management of such high-impact injuries, not only rigid fixation for unstable fractures, but less invasive fixation to preserve general condition and soft tissue are needed.

To treat thoracolumbar burst fracture, minimally invasive posterior fixation surgery with percutaneous pedicle screws (PPS) is widely used and enables early ambulation[2)]. In contrast, for the surgical treatment of unstable sacral fractures,

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Table.

Case no.	Age Sex	Cause	Injury		Preoperative neurological impairment	Duration to surgery	Final follow-Up		
			Head Chest Abdomen	Spino-Pelvic Fructures			M	Clinical outocome	Radiological outcome
1	50 F	Suicide Fall from 5th floor	Brain hemorrhage Hemopneumothorax (L) Liver injury	Unstable sacral (H-shaped, AO: C3) Thoracolumbar (L1 and L2) burst	Undiagnosed	28 days	12	T-cane walk BBD (-)	Thoracolumbar: Union Sacrum: Union
2	25 F	Suicide Fall from 7th floor	Hemopneumothorax (R) Sacral artery injury	Unstable sacral (H-shaped, AO: C3) Thoracolumbar (L1) burst	Undiagnosed	10 days	12	T-cane walk BBD (-)	Thoracolumbar: Union Sacrum: Delayed union
3	43 F	Suicide Fall from 4th floor	Hemopneumothorax (L) bilateral internal iliac arteries, sacral artery, and lumbar artery injury	Unstable sacral (H-shaped, AO: C3) Thoracolumbar (L1, L3, and L4) burst	Undiagnosed	7 days	12	T-cane walk BBD (+)	Thoracolumbar: Union Sacrum: Union

various surgical techniques including transiliac fixation and spinopelvic fixation have been reported. There are some concerns that transiliac fixation can lead to weakness against axial loading. Spinopelvic fixation using Galveston techniques can obtain more rigid fixation, but there are concerns that these techniques cause complications because they are invasive of soft tissue. In the present study, we present a technical report of 3 cases of suicidal jumper's fracture with thoracolumbar burst fracture treated with minimally invasive posterior fixation surgery, which is a combination of PPS and the mini-open Galveston technique (Table).

Technical report

PPS technique

The thoracolumbar burst fractures were essentially treated with one above one below fixation without neural decompression. We made 4 small incisions for PPS (Veper2 system, DePuySyenthes, CA, USA) and determined the entry point of the PPS using C-arm imaging. We used tap needles to insert a guide-wire under AP view and lateral view of C-arm imaging. After guide-wire insertion, a cannulated polyaxial screw was inserted over the guide-wire.

Mini-open Galveston technique

We treated unstable sacral fractures with minimally invasive posterior fixation surgery, using a combination of PPS and mini-open iliac screws or the so called mini-open Galveston technique. We inserted bilateral L4 and L5 PPS as described above. We exposed the posterior superior iliac spine with a 3 cm skin incision. We removed cortical bone from the posterior superior iliac spine so that the screw head did not protrude and irritate the overlying skin and then inserted iliac screws bilaterally (Expedium system, DePuySyenthes, CA, USA). We pushed titanium alloy rods into the paravertebral muscle bilaterally through a cranial to caudal rod guide sleeve for PPS. We could usually connect the rod and iliac screw under direct vision (Fig. 1), but if this was difficult, we could use an offset connector as necessary. We did not essentially perform transverse fixation and neural decompression. When necessary, we could connect PPS for thoracolumbar burst fracture and mini-open Galveston technique using one rod in patients with an L3 fracture (Fig. 1). Cross-links (transverse-connectors) to augment posterior spinal-constructs were not routinely used.

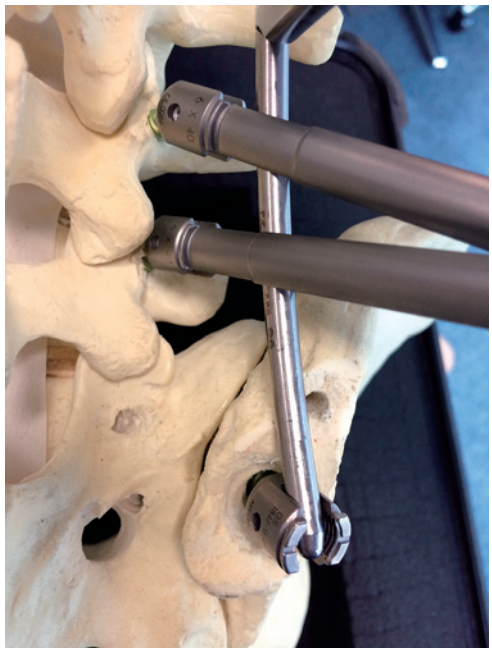

Figure 1. Percutaneous pedicle screw and mini-open Galveston technique.
We could connect PPS of lower lumbar and iliac screws easily using one rod under direct vision.

This fixation for thoracolumbar and sacral fractures was temporary. Therefore, we did not use any bone graft and planned to remove the instrumentation after these fractures

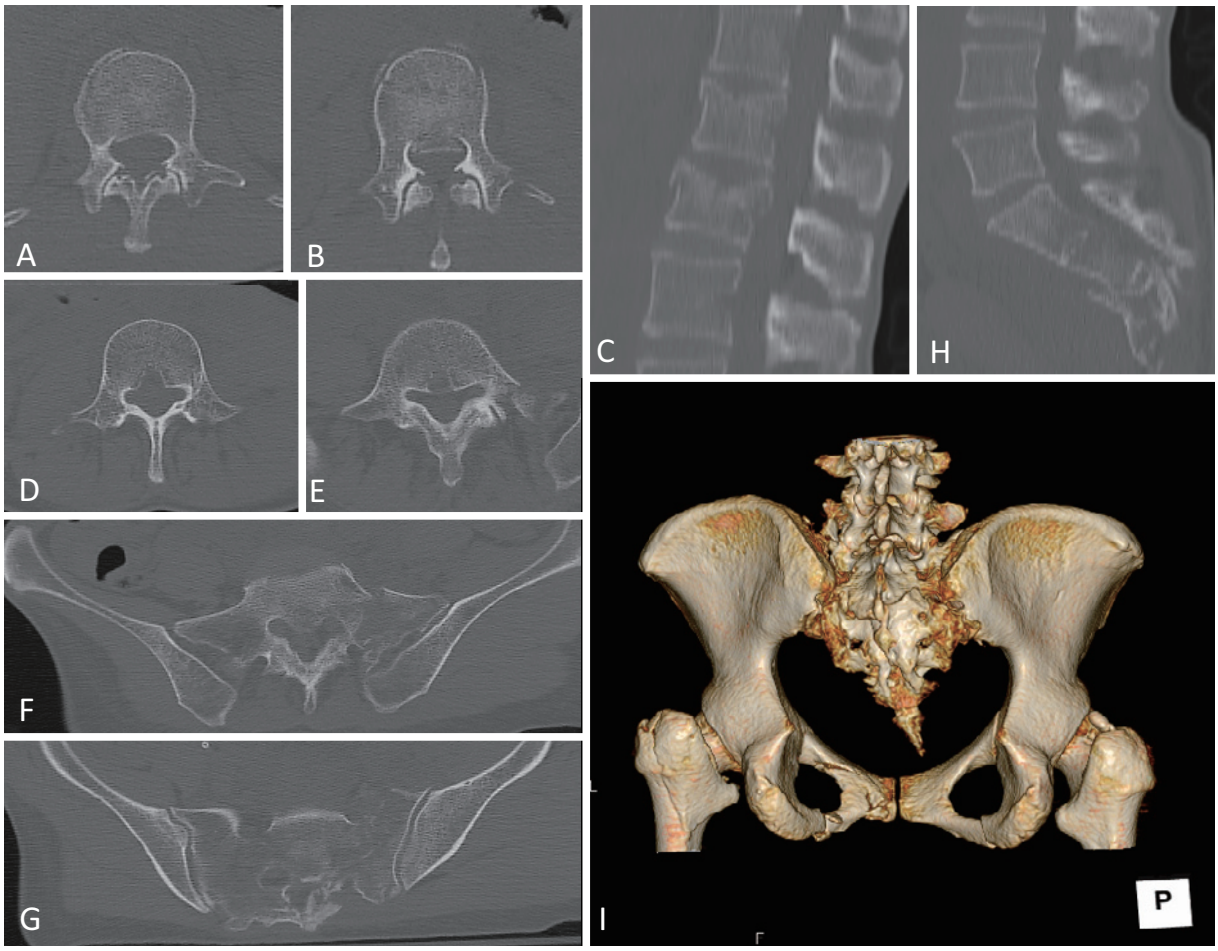

Figure 2. Preoperative computed tomography (CT) images of the patient in Case 1.
Axial view of L1 [A], L2 [B], L4 [D], L5 [E], and sacrum [F, G], sagittal view of thoracolumbar [C], lumbosacral [H], and 3D reconstruction images of the pelvis [I]. There were burst fractures of L1 and L2 [A–C], and the right transverse process fracture of L4 [D, I], the left transverse process fracture of L5 [E, I], and H-shaped sacral unstable fracture [F–I].

had healed.

Case reports

Case 1

A 50-year-old woman was injured by a fall from the 5th floor of a building as the result of a suicide attempt and was hospitalized immediately. On initial assessment, she was found to have traumatic hemorrhagic shock and multiple injuries including hemopneumothorax, abdominal bleeding because of liver injury, brain hemorrhage, unstable sacral fracture, thoracolumbar burst fracture, and multiple other fractures, including multiple fractures of the ribs, left elbow fracture, left femoral neck fracture, bilateral calcaneus fracture, and mandible fractures. Her neurological symptoms were not clear because of disturbance of consciousness. Emergency hemostasis on thoracotomy was performed for her hemopneumothorax because we could not control bleeding in her chest. For the hemoperitoneum, we tried to control bleeding using transcatheter arterial embolization (TAE), but could not. Therefore, emergency laparotomy and gauze packing were used to control bleeding. We also performed external fixation for pelvic ring instability.

The patient had a cerebral hemorrhage, but this was treated conservatively as a result of medical treatment policy. Following the emergency treatments, she had recovered from traumatic hemorrhagic shock.

Computed tomography (CT) of the thoracolumbar region revealed anterior and posterior wall fractures of the L1 and L2 vertebrae. The extent of spinal canal compromise was 19% in L1 and 42% in L2. We diagnosed these burst fractures as AO classification type A3 (Fig. 2A-C). CT imaging of the lumbopelvic region revealed right transverse process fracture of L4, left transverse process fracture of L5, H-shaped sacral fracture, and bilateral ischium and pubis fractures. We diagnosed these pelvic fractures as AO classification type C3 (Fig. 2D-I).

We planned to perform spinopelvic fixation surgery for thoracolumbar fracture and unstable sacral fracture to obtain early stabilization of these fractures and early ambulation. However, because of the poor general condition of the pa-

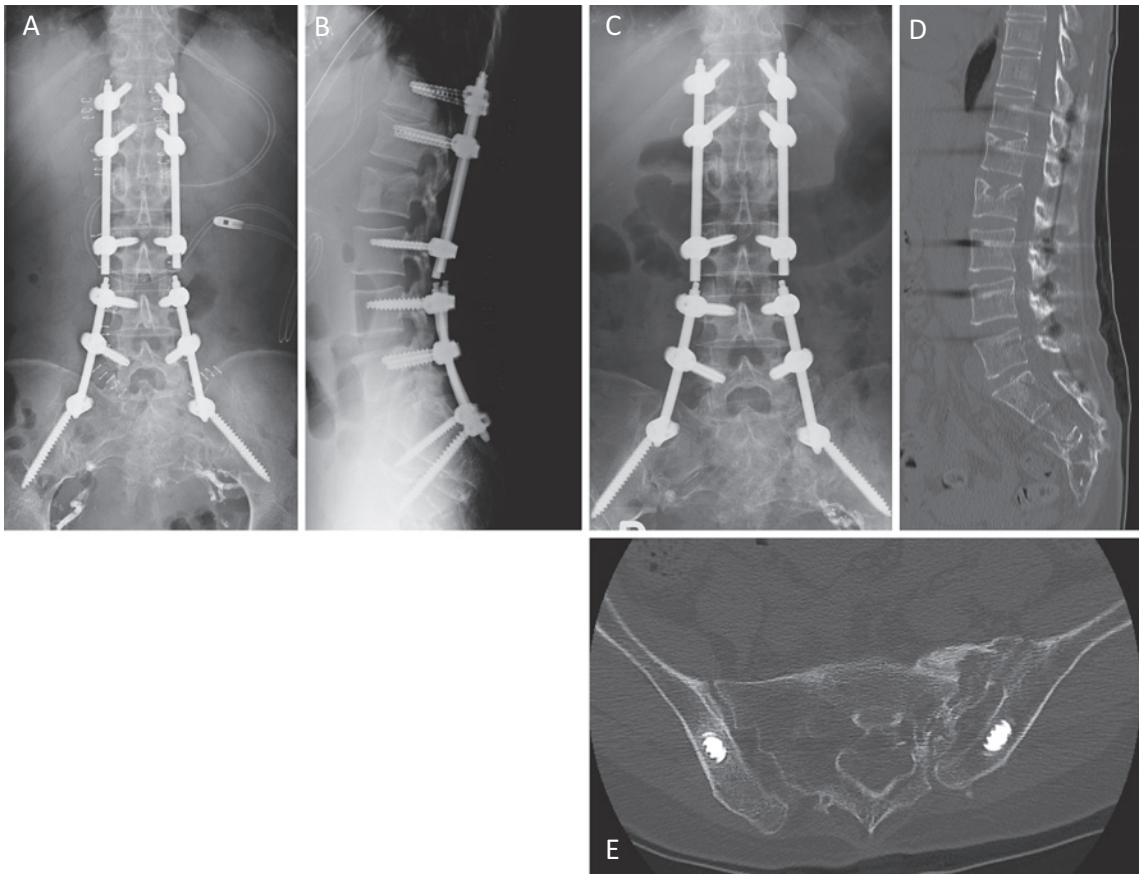

Figure 3. Postoperative X-ray images and CT of the patient in Case 1.
AP view [A], lateral view [B] of the X-ray image at the time after surgery and AP view of X-ray image [C], sagittal CT view of spine [D], and axial CT view of sacrum [E] at final follow-up (one year after surgery). T12 to L3 instrumented posterior spinal fusion with PPS for L1 and L2 burst fracture, and L4 to ilium instrumented posterior spinopelvic fixation with L4 and L5 PPS and mini-open iliac screws for unstable sacral fracture were performed [A, B]. One year after surgery at the final follow-up, radiographic findings revealed almost healed L1 and L2 fractures, and an unstable sacral fracture [C–E].

tient, including pneumonia and hepatic dysfunction, treatment was delayed until 28 days after injury. We then performed T12 to L3 instrumented posterior spinal fusion with PPS for L1 and L2 burst fracture, and also L4 to ilium instrumented posterior spinopelvic fixation with L4 and L5 PPS and mini-open iliac screws for unstable sacral fracture as described above (Fig. 3A, B). The operative time was 2 h 15 min, and the blood loss was 100 mL. Her early emergence from bedrest contributed to the improvement of her general condition. One year after surgery at the final follow-up, she was able to walk with a T-cane without any motor, bladder, or bowel dysfunction. X-ray imaging and CT at the final follow-up revealed almost healed L1 and L2 fractures, and an unstable sacral fracture (Fig. 3C-E).

Case 2

A 25-year-old woman was injured by a fall from the 7th floor of a building as a suicide attempt and was hospitalized immediately. On initial assessment, she was found to have traumatic hemorrhagic shock and multiple injuries including right hemopneumothorax, abdominal bleeding because of a sacral artery injury, unstable sacral fracture, thoracolumbar burst fracture, bilateral calcaneus fractures, and multiple fractures of the limbs. We performed chest drainage for hemopneumothorax, TAE for abdominal bleeding, and external fixation for pelvic ring instability.

CT revealed that there was an L1 burst fracture whose spinal canal compromise was 32%, right transverse process fracture of L4, bilateral transverse process fracture of L5, and unstable H-shaped sacral fracture (Fig. 4A, B). We diagnosed an L1 burst fracture of AO classification type A3, and a pelvis fracture of AO classification type C3. Ten days after injury we performed T12 to L2 instrumented posterior spinal fusion with PPS for the L1 burst fracture, and L4 to ilium instrumented posterior spinopelvic fixation with L4 and L5 PPS and mini-open iliac screws for the unstable sacral fracture as described above. In this case, we used an offset connector to connect PPS and iliac screws (Fig. 4C, D). The operative time was 3 h 7 min, and the blood loss was 137 mL. The patient was able to sit in a wheel chair on day 7 after surgery, and her early ambulation contributed to the improvement of her general condition. One year after surgery at final follow-up, she was able to walk with a T-cane without any motor, bladder, or bowel dysfunction. X-ray im-

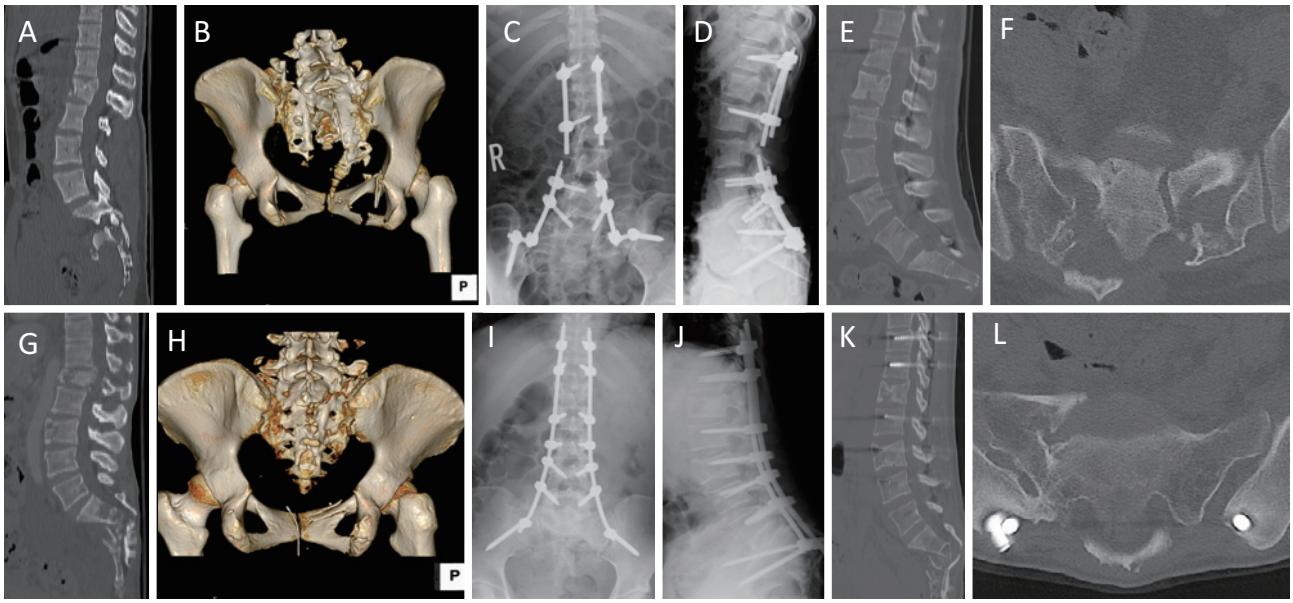

Figure 4. Radiographic findings in Cases 2 and 3.
Case 2: Preoperative CT sagittal view [A] and 3D reconstructed images of the pelvis [B] showing an L1 burst fracture, right transverse process fracture of L4, bilateral transverse process fracture of L5, and unstable H-shaped sacral fracture. Postoperative AP X-ray image [C] and lateral X-ray image [D]. T12 to L2 instrumented posterior spinal fusion with PPS for L1 burst fracture, and L4 to ilium instrumented posterior spinopelvic fixation with the mini-open Galveston approach for unstable sacral fracture. Postoperative sagittal CT view of the spine [E] and axial CT view of the sacrum [F] at final follow-up (one year after surgery). The CT view of the spine shows an almost healed L1 fracture, but the CT view of the sacrum reveals a delayed union.
Case 3: Preoperative CT sagittal view [G] and 3D reconstructed images of the pelvis [H] showing L1, L3, and L4 burst fractures, bilateral transverse process fractures of L5, and an unstable H-shaped sacral fracture. Postoperative AP view [I] and lateral view [J] of X-ray images. T11 to ilium instrumented posterior spinopelvic fixation with PPS and mini-open Galveston approach for L1, L3, and L4 burst fractures, and the unstable sacral fracture. Postoperative sagittal CT view of the spine [K] and axial CT view of the sacrum [L] at final follow-up (one year after surgery) shows almost complete healing.

aging and CT at the final follow-up revealed an almost healed L1 fracture, but delayed bone union of the unstable sacral fracture.

Case 3

A 43-year-old woman was injured by a fall from the 4th floor of a building as a suicide attempt and was hospitalized immediately. On initial assessment, she was found to have traumatic hemorrhagic shock, and multiple injuries including abdominal bleeding because of injuries to her bilateral internal iliac arteries, sacral artery, and lumbar artery, a thoracolumbar burst fracture, unstable sacral fractures, lung contusion, and multiple fractures of the limbs. We performed TAE for abdominal bleeding, and external fixation for pelvic ring instability.

CT revealed that there were L1, L3, and L4 burst fractures, bilateral transverse process fractures of L5, and an unstable H-shaped sacral fracture (Fig. 4E, F). We diagnosed L1, L3, and L4 burst fractures as AO classification type A3, and the pelvis fracture as AO classification type C3. Seven days after injury, we performed T11 to ilium instrumented posterior spinopelvic fixation with T11, T12, L2, L3, L4, and L5 PPS and mini-open iliac screws for L1, L3, and L4 burst fractures and the unstable sacral fracture, as described above. In this case, we connected T11 PPS to iliac screws using a single rod, because there were also L3 and L4 burst fractures (Fig. 4G, H). The operative time was 3 h 24 min, and the blood loss was 695 mL. The patient was able to sit in a wheel chair on day 7 after surgery, and her early ambulation contributed to the improvement of her general condition. One year after surgery at the final follow-up, she was able to walk without any support or motor dysfunction, but moderate bladder and bowel dysfunction remained. X-ray imaging and CT at the final follow-up revealed almost healed L1, L3, L4, and sacral fractures.

Discussion

We present 3 cases of suicidal jumper's fracture (unstable sacral fracture) with thoracolumbar burst fracture, treated with minimally invasive posterior fixation surgery, which is a combination of PPS and the mini-open Galveston technique. In 1 of the 3 cases there was delayed union of the unstable sacral fracture, and in 1 of the 3 cases, moderate bladder and bowl dysfunction remained. However, all patients attained early and rigid stabilization, and early ambulation, which contributed to an improvement in their general condition.

There are conventional open and percutaneous approaches to posterior instrumented fixation surgery for thoracolumbar burst fractures. PPS fixation showed a better outcome compared with open surgery because it is less invasive in patients with polytrauma[3]. PPS fixation for thoracolumbar burst fracture with multiple injuries showed a better outcome than open surgery in a meta-analysis[4]. By contrast, the advantage of an open approach is that decompression surgery can be added depending on the patient's neurological symptoms[5]. Narrowing of the spinal canal can be progressively relieved by natural remodeling of the fragments retropulsed into the spinal canal in patients with thoracolumbar burst fractures and may eliminate the need for decompression surgery for thoracolumbar burst fracture with neurological symptoms[6]. Patients with incomplete paraplegia who received posterior fusion surgery without decompression for thoracolumbar burst fractures improved by at least one modified Frankel grade[7]. These findings indicate that PPS fixation surgery without decompression would be effective and less invasive for thoracolumbar burst fracture even if the patients have neurological symptoms.

Whether anatomical reduction, decompression and fixation surgery is needed for unstable sacral fractures is controversial. Gansslen et al. have reported the efficacy of anatomical open reduction and internal fixation for unstable sacral fractures, especially in cases with neurological deficit[8]. Furthermore, Denis et al.[9] concluded that surgical decompression permitted significantly better neurological recovery than nonsurgical methods. By contrast, Sabiston et al. concluded that treatment for sacral fracture should be conservative because neurological deficit tends to improve spontaneously[10]. Two of 3 patients recovered neurological symptoms including bladder and bowel dysfunction at the final follow-up. In addition, Schildhauer et al. reported the wound-related complication rate of open reduction surgery for sacral fracture to be 16% and open reduction might be invasive for soft tissue[11]. Therefore, especially in patients with multiple trauma whose general condition is poor, open reduction and decompression surgery for sacral fracture with neurological deficits would not be necessarily required. However, in our Case 2, bone union of sacral fracture was delayed because of severe displacement of the sacral fracture. Such cases might need open reduction and internal fixation when their general conditions allow.

Other surgical strategies for suicidal jumper's fracture (unstable sacral fracture) include transiliac fixation and spinopelvic fixation. M-plate fixation[12] and iliosacral screws[13] in transiliac fixation have the advantage of being less invasive for soft tissue. However, unstable sacral fracture is usually complicated by lower lumbar transverse process fractures that indicate instability for axial loading. There is concern that transiliac fixation for axial loading is weak. Therefore, spinopelvic fixation is recommended for unstable sacral fractures with instability for axial loading. The Galveston technique is well-known to be a good surgical strategy for spinopelvic fixation of unstable sacral fracture[14]. However, the original Galveston technique causes extensive damage to the soft tissue on the sacrum, thereby causing wound-related complications including infection[15,16]. The mini-open Galveston technique is less invasive for soft tissue, because only a 3 cm skin incision is needed to expose the posterior superior iliac spine when inserting iliac screws. Koshimune et al. have reported good results for the mini-open Galveston technique using a navigation system[17]. However, in the present study, we used C-arm imaging, and not special equipment including a navigation system, and more easily obtained the rigid fixation required, so that the mean operative time was 175 min including fixation for thoracolumbar burst fracture and unstable sacral fracture, compared with 208 min for fixation of the unstable fracture alone as described by Koshimune et al. Another advantage of this technique was that it could be connected to fixation for thoracolumbar burst fracture according to the type and location of thoracolumbar fracture as in our Case 3. Truong et al. concluded that early ambulation of surgical patients with multiple trauma in intensive care units whose general condition was poor had the potential to reduce short-term impairment[18]. In their randomized controlled study, Schweickert et al. found that early ambulation and rehabilitation of patients with critical illness was safe and resulted in better functional outcomes[19]. Based on these findings, we recommend a less invasive and safer strategy with rigid fixation, so that patients could ambulate early and which would contribute to improvement of their general condition. Therefore, we consider early stabilization of spinopelvic instability to be more important than reduction and correction of spinopelvic fractures in such patients with multiple trauma. To address these points, a combination of PPS and the mini-open Galveston technique would be a good approach for treating spinopelvic instability in such patients.

From the view point of reduction and fixation, Halawi concluded that the optimal timing for fixation remained unclear, but recommended early stabilization[20]. By contrast, from the viewpoint of the recovery of neurological impairment, in their systemic review Anderson et al. concluded that there was scant evidence that surgery within 24 h of injury produced significantly greater improvement, and moderate evidence that surgery within 2 weeks of injury produced significantly greater improvement[21]. However, in their prospective study, Konieczny et al. found that early surgery within 72 h of traumatic injury to the thoracic spine in patients with severe thoracic trauma increased the mortality rate[22]. Based on these reports, the surgery should be performed at the earliest safe situation for the patient.

However, there were some limitations of this technique. One was that we could not obtain open reduction of the unstable sacral fracture and add decompression surgery in patients with neurological symptoms. The second was that any cross-links (transverse-connectors) to augment posterior spinal-constructs were not used routinely, so that fixation might be a little weak. The third was that the Galveston technique could not achieve good reduction, especially of

angular displacement of the sacrum. To reduce this angular displacement, ideally we need open reduction for sacral fractures. However, Gribnau et al. reported progressive deformity after unstable sacral fractures causing chronic pain, and that the pain influences the general health status of patients[23]. Open reduction is more invasive for patients whose general condition is poor. Moreover, it is not clear how much displacement is acceptable. Further study is needed to evaluate the quality of life of patients including pain, walking ability and bladder and bowel dysfunction after such unstable sacral fractures and to clarify this point. The fourth was that this mini-open Galveston technique limits reduction of the sacral fracture. We consider spinal instrumentation, especially polyaxial screws, which we use in this technique, as good for rigid fixation, but not for reduction. How much reduction of the sacral fracture can be attained with this mini-open technique remains unclear. Further study is needed to clarify this point.

Conclusion

We present 3 cases of suicidal jumper's fracture with thoracolumbar burst fracture, treated with minimally invasive posterior fixation surgery, which is a combination of PPS and the mini-open Galveston technique. The PPS and mini-open Galveston technique might be a good approach to fixation because it is minimally invasive and provides moderately rigid fixation. In addition, this technique can be connected to fixation for thoracolumbar burst fracture according to the type and location of thoracolumbar fracture.

Conflicts of Interest: The authors have no conflicts of interest or funding to declare.

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