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Surgical Treatment of Sacral Fractures: A Case Series Study

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Background: The sacrum bone is an integral part of pelvis and spinal column. It protects lumbosacral neurologic plexus and maintains the spinal column and pelvic alignment. Therefore, injury to the sacrum may lead to neurologic deficit, pain and disability. Due to difficulties in radiologic diagnosis and associated injuries, sacral fractures are usually missed or diagnosed late.
Objectives: To evaluate the clinical and functional outcome of surgical treatment of high-energy traumatic sacral fractures.
Patients and Methods: All patients with sacral fractures, who had undergone surgical treatment, were evaluated retrospectively and data were collected. Fracture type, preoperative and postoperative neurologic examination, according to the American spinal injury association (ASIA) score and Gibbons' classification and visual analogue scale (VAS) were evaluated. In addition, postoperative complications, such as infection, deep venous thrombosis (DVT), rod breakage, screw loosening and dislodgment were assessed.
Results: Of the 27 patients with sacral fracture that were treated surgically, 15 (55.4%) patients were female and 12 (44.6%) were male. Fourteen (51.8%) patients underwent percutaneous iliosacral screw fixation and 13 (48.1%) patients underwent spinopelvic fixation. Three (11.1%) patients had neurologic deficit. After neurologic decompression, two of them recovered completely (with preoperative Gibbon's grade 2, 3) and one of them, with Gibbons' grade 4, improved incompletely in motor power and also remained incontinent after a year postoperatively. None of them developed postoperative infection, DVT, rod breakage or screw loosening or breakage. Only one patient, in the unilateral spinopelvic fixation group, developed asymptomatic rod dislodgment from distal (iliac) fixation. In all patients, VAS score changed substantially from mean 8, preoperatively, to mean 1, postoperatively.
Conclusions: For no displaced or minimally displaced sacral fractures and fractures without comminution, especially in young and non-osteoporotic patients, (Denis type 1 and 2) percutaneous iliosacral screw fixation could be an ideal treatment. For Denis type 3, spinopelvic dissociation, comminuted Denis type 1 and 2 and for sacral fracture in osteoporotic or elder patients, spinopelvic fixation may be the treatment of choice, with acceptable outcome.

Keywords: Iliosacral Screw; Spinopelvic Fixation; Sacrum; Bone Screw; Lumbosacral Plexus; Fracture Fixation

1. Background

The sacrum bone is an integral part of the spinal column and pelvic ring. The lumbosacral neurologic function is protected by the sacrum and it maintains spinal column and pelvic alignment. For these reason, injuries to the sacrum may result in deformity, chronic pain and loss of lower extremity, bowel, bladder and sexual function. Therefore, the treatment of sacral fractures requires optimizing both neurologic and structural outcome, while also implicating a comprehensive understanding of neural decompression and skeletal reconstruction techniques (1). The severity of sacral fracture varies from insufficiency fracture in osteoporotic patients, to complex fracture pattern, resulted from high-energy trauma, such as motor vehicle accident or fall from height (1-6).

The majority of sacral fractures occur in combination with pelvic fractures and the rest of them, representing only a small percent, occur either isolated or in combination of noncontiguous thoracolumbar fractures. The incidence of sacral fracture, accompanied by pelvic fracture, ranges from 40% to 50% (1, 6-10). Because of the close relationship of the sacrum and neurologic function of lower extremity and bowel, bladder and sexual function, diagnosis and treatment of sacral fracture is very important and is very challenging (6). According to the literature, sacral fractures, in 30% of patients with neurologic deficit and in 50% of patients with normal neurologic examination, had been missed (5, 6, 8, 9). Therefore, comprehensive history taking and physical examination, in combination with using diagnostic modalities and high index of suspicion of physician are mandatory for the prevention of complications, which may accompany sacral fracture, in trauma patients (5).

2. Objectives

The aim of this study was to evaluate outcomes of patients with sacral fracture, who underwent surgical treatment.

3. Patients and Methods

From March 2013 to December 2014, all patients who had

been operated due to sacral fractures were evaluated, retrospectively. Fractures type, preoperative and postoperative neurologic exam according to the American spinal injury association (ASIA) score and Gibbons' classification, visual analogue scale (VAS), and clinical condition are evaluated. Fracture types were assessed according to the x-ray (anteroposterior, inlet and outlet of pelvis) and CT scan, with sagittal, coronal, axial and 3D reconstruction. Sacral fractures were classified according to the Roy-Camille (11) and Denis classifications (12). A single spine surgeon, under general anesthesia and elective condition, operated all patients, after stabilization of patients. Spinopelvic fixation was performed in prone position and percutaneous iliosacral screw insertion was done in supine position. For patients with comminuted sacral fractures, Roy-Camille type 1, 2 and 3 fractures, spinopelvic fixation was done and, for the patients with minimal or non-displaced Denis type 1 and 2, percutaneous iliosacral fixation was performed. Postoperative follow-up was based on routine program at 2, 6 and 12 weeks, and 6 and 12 months after operation. Description of Gibbons', Roy-Camille and Denis classifications are illustrated in Tables 1 - 4.

3.1. Surgical Techniques

For bilateral spinopelvic fixation, after general anesthesia, the patients were placed in prone position. With posterior midline incision, pedicular screws were inserted in the pedicle of L_4 and L_5, bilaterally (four points fixation in proximal) and one or two screws were inserted in the iliac bone, from entry point of posterior superior iliac spine (PSIS). We measured the length of screw preoperatively, by picture archiving and communication system (PACS), from PSIS to the point, which is two centimeters above the greater sciatic notch. We inserted one or two screws in each iliac wing, in thin and obese patients, respectively. All iliac screws were sunk in the posterior inferior iliac spine, to prevent hardware skin stimulation. Then, lumbar screws connected to the iliac screw, by a rod and bilateral rods, were connected together by cross-link. For patients with Roy-Camille fractures type 1, 2 and 3, this technique was applied. For patients with unilateral comminuted sacral fracture, Denis type 1 and 2, unilateral spinopelvic fixation was performed (1). For patients with neurologic deficit, direct decompression by laminectomy and foraminotomy were done, in prone position, during spinopelvic fixation.

For patients with minimal or non-displaced Denis type 1 and 2 fractures and with no or minimal comminution, definitive fixation was performed with percutaneous iliosacral screw, in supine position. For this technique, after appropriate anesthesia, in supine position, cannulated 7.3 mm partial threaded screws, with 100 - 110 mm length, were placed under the control of fluoroscopy C-arm. The entry point for percutaneous S1 screw was about four-finger width anterolateral from PSIS. For transforaminal fracture Denis 2, we did not use washer to decrease compressive effect through the fracture site, although for Denis type 1, the washer was used to compress the fracture site, to enhance union. The drainage tube was removed 48 hours after surgery. Antibiotic, generally first generation of cephalosporin, was continued 48 hours postoperatively. Chemoprophylaxis for deep venous thrombosis (DVT) was started postoperatively, in patients for whom neurologic decompression was not performed and continued until the patients mobilized. After definitive surgical fixation, early mobilization was started. Early postoperative partial weight bearing was encouraged, when associated injuries allowed, after 8 - 12 weeks full weight bearing was allowed, according to the fracture type and associated injuries. Plain X-rays of all patients were obtained 2 weeks, 6 weeks, 12 weeks, 6 months and 12 months after operation. In every postoperative visit, wound status, VAS score, recovery of neurologic function and union were evaluated. Neurologic recovery was assessed according to the Gibbons' grading.

Table 1. American Spinal Injury Association Scores for Neurologic Deficit in Patients With Spinal Cord Injury

Score	Sensory	Motor
A	-	-
B	+	-
C	+	Less than 50% of motor groups have < 3.5 motor power
D	+	More than 50% of motor groups have >3.5 motor power
E	Normal	Normal

Table 2. Gibbons' Classification of Neurologic Deficit in Patients With Sacral Fracture

Fracture Grade	Criteria
Grade 1	Normal
Grade 2	Sensory deficit
Grade 3	Motor defict
Grade 4	Bowel and bladder dysfunction

Table 3. Roy-Camille Classification of Sacral Fractures

Fracture	Criteria
Type 1	Only flexion deformity (kyphosis angulation) in fracture site
Type 2	Flexion deformity and translation of fracture
Type 3	Complete anterior translation of lumbar spine and upper part of sacrum
Type 4	Impaction of upper segment of sacrum due to the axial load

Table 4. Denis Classifications of Sacral Fracture

Fracture	Criteria
Type 1	Fracture in sacral, lateral to the sacral foramens
Type 2	Fracture through the sacral foramens, transforaminal fracture
Type 3	Fracture medial to the foramens and through the canal

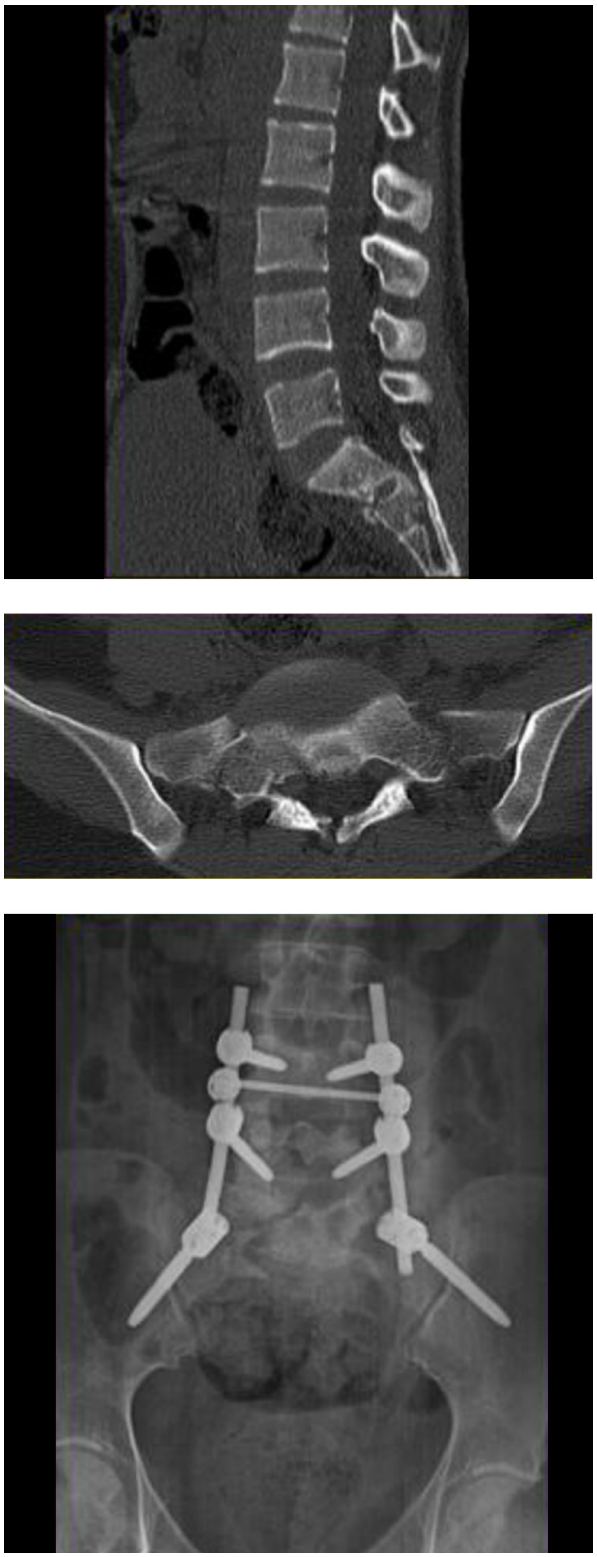

Figure 1. Roy-Camille Type 1; Bilateral Spinopelvic Fixation

4. Results

Twenty seven patients, fifteen females (55.4%) and twelve males (44.6%), with sacral fracture, underwent surgical treatment. Ages ranged from 16 to 60 years and the mean age was 32.5 years. The causes of trauma were motor-vehicle collisions in 18 cases (68%) and falling from height in 11 cases (32%). Sacral fractures were classified according to the Denis and Roy-Camille classifications. Denis type 1 in five (18.5%), Denis type 2 in 16 (58.2%) case and Denis type 3 in one (3.7%) case were detected. According to the Roy-Camille classification, two, two and one cases had sacral fractures type 1, 2 and 3, respectively. The frequency of fractures has been illustrated in Table 5.

Fourteen patients (51.9%) underwent percutaneous iliosacral screw fixation and thirteen patients (48.1%) underwent spinopelvic fixation. Of the thirteen patients for whom spinopelvic fixation was done, six (46.2%) patients had U-type sacral fracture (Roy-Camille type 1, 2 and 3) and, for them, bilateral spinopelvic fixation was done, while for seven (53.8%) patients, with comminuted sacral fracture (Denis type 1, 2, 3 fracture), unilateral spinopelvic fixation was performed.

Three (11.1%) patients had neurologic deficit ASIA, score B and C, according to the ASIA classification, or Gibbons type 3 and 4, according to the Gibbons classification. For patients with neurologic deficit, neurologic decompression by laminectomy and foraminectomy were performed. Two patients with neurologic deficit had spinopelvic dissociation (Roy-Camille type 2 and 3) and one patient (with Gibbons' grade 4 neurologic deficit) had comminuted sacral fracture Denis type 3 fracture, and all of them underwent spinopelvic fixation.

Regarding complications, none of our patients developed any early or late infection, rod breakage and screw breakage. There was only an asymptomatic rod dislodgment from iliac, in a patient with unilateral spinopelvic fixation. The VAS score was decreased dramatically postoperatively, from mean scores of 8, preoperatively, to 1, postoperatively. There was no difference between patients who underwent spinopelvic fixation, with two or four distal point fixation, in terms of complications, such as device failure, rod breakage, loosening, union rate and VAS. None of our patients, in both groups, developed VDT postoperatively. Some of our cases with different types of sacral fractures have been illustrated in Figures (1 - 5).

Table 5. Frequency of Sacral Fractures in our Series

Fracture Type	Values [a]
Denis 1	5 (18.5)
Denis 2	16 (59.2)
Denis 3	1 (3.7)
Roy-Camille 1	2 (7.4)
Roy-Camille 2	2 (7.4)
Roy-Camille 3	1 (3.7)
Total	27 (100)

[a] Data are presented as No. (%).

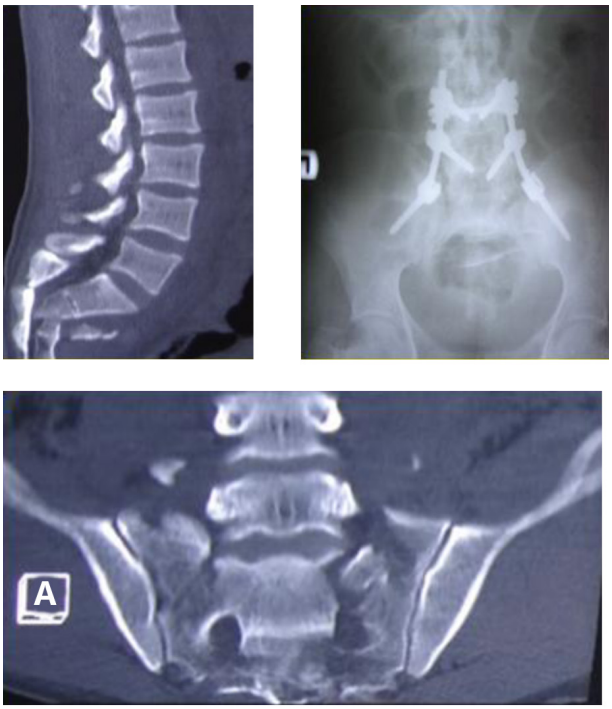

Figure 2. Roy-Camille Type 2 (U-Type); Bilateral Spinopelvic Fixation

Figure 3. Roy-Camille Type 3; Bilateral Spinopelvic Fixation

Figure 4. Comminuted Sacral Fracture; Denis Type 3; Unilateral Spinopelvic Fixation

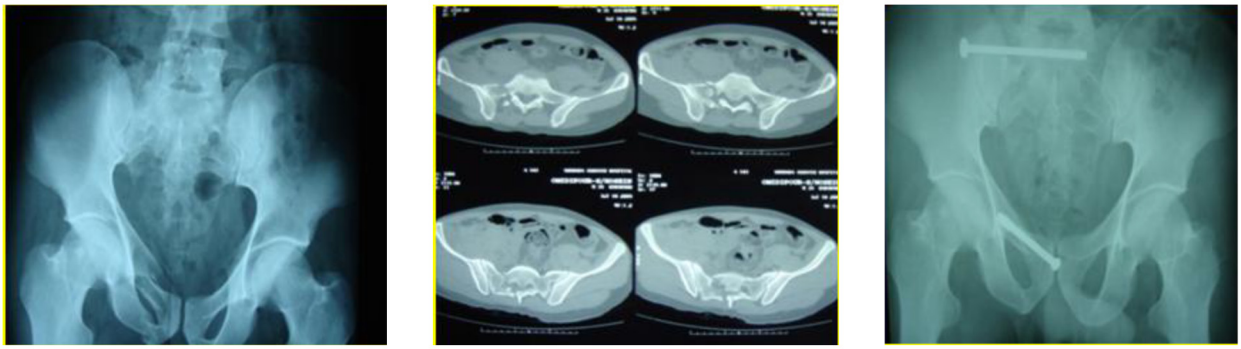

Figure 5. Denis Type 2; Percutaneous Iliosacral and Superior Ramus Screw Fixation

5. Discussion

Sacral fractures are poorly recognized, because of difficulty in radiological evaluation and combined severe injuries, associated with these fractures. In our series, all traumatic patients, who suffered from sacral fracture, were included in this study. Sacral fractures were diagnosed by X-ray (antero-posterior, inlet and outlet views of pelvis) and CT scan, and classified according to the Denis and Roy-Camille classifications. In patients with neurologic deficit, magnetic resonance imaging (MRI) was requested. Neurologic examination for all patients was done and competency of anal sphincters was assessed by digital rectal examination and electromyogram-nerve conducting studies were not carried in all patients.

The ideal treatment of sacral fracture remains unknown (7, 13). Earlier studies demonstrated reasonable outcomes, with either non-operative or surgical methods. However, over the last 20 years, no constant treatment algorithm for these severe injuries has been introduced (7, 13). Bellabarba et al. (7) showed that rigid spinopelvic fixation permitted reliable fracture reduction of the lumbosacral spine and posterior pelvic ring, allowing early mobilization, without external support, and neurologic recovery in the majority of patients. They also stated that infection, wound healing, and asymptomatic rod breakage, were the most reported complications regarding this entity, however without long-term sequels.

In the review article, which was done by Bydon et al. (6), they stated that, due to the complex nature of sacral fractures, ideal treatment is challenging and also, they added that, although the fusion rate was high, long-term morbidities, such as neurologic deficit and chronic pain, were persistent in many patients.

Gribnau AJ et al. (14) reported eight polytraumatized patients, with U-shaped sacral fracture, in which definitive treatment included either percutaneous iliosacral fixation (n = 2), triangular osteosynthesis with (n = 4) or without (n = 1) transsacral plating. They concluded that sacral fractures are rare and heterogeneous injuries and surgical treatment depended mainly on fracture type, associated spinal fracture and the surgeon's preference. They also reported that long term quality of life is subjected by mood disorders, pain and moderate mobility problems.

Sacral fractures have a high incidence of neurologic deficit, ranging from isolated single nerve root injury, to complete caudal equine syndrome (CES) (9). Hence, comprehensive neurologic examination to find any neurologic deficit is mandatory, preoperatively. While finding the neurologic deficit, decompression is necessary. Neurologic decompression can be done directly or indirectly. Direct decompression is made by laminectomy or foraminotomy and indirect decompression by reduction of fractures (1, 3, 5, 6, 8, 9).

In our patients with neurologic deficit, direct decompression was done in two patients with root injury and the outcome was good, as they recovered after mean of 4 weeks from surgery, although in a patient with CES, the outcome was not favorable and she was still incontinent after 12 months, postoperatively.

Hunt et al. (15) reported four cases with U-shaped sacral fractures that underwent early surgical treatment. Due to spinopelvic dissociation and neurologic deficits in their series, laminectomy and spinopelvic fixation were done. In addition, they reported that no complication was encountered because of fixation. They also reported that this kind of fixation allow early mobilization of polytraumatized patients.

Dalbayrak et al. (5) reported 10 cases with pelvic fractures, together with sacral fractures and spinopelvic instability, that underwent spinopelvic fixation. They showed that preoperative VAS and Oswestry index were changed dramatically and concluded that aggressive stabilization and fixation must be done, as soon as possible and without any delay, in patients who suffered from spinopelvic instability.

In our series, we applied spinopelvic fixation for patients with spinopelvic dissociation. Roy-Camille type 1, 2, 3 and percutaneous iliosacral fixation were utilized for patients

with Denis type 1 and 2 sacral fracture, without comminution of fracture site, and also in the absence of osteoporosis. In the other words, percutaneous iliosacral screw was applied in young patients, with no displaced simple unilateral sacral fracture and intact neurological status. Nork et al. (16) showed successful use of percutaneous iliosacral screw in patients with minimal or non-displaced U-shaped sacral fractures. Other authors have believed that this technique is not suitable for patients with the more unstable, displaced and comminuted fractures, such as Roy-Camille type 2, 3 and 4 sacral fractures (17).

In conclusion, sacral fractures are rare and detection of these potentially complicating fractures is very important. A high index of suspicion and use of diagnostic modalities, such as X-ray, CT scan, MRI and, in certain instance, electrodiagnostic studies, are mandatory to recognize these fractures. In terms of treatment for non-displaced Denis type 1 and 2, it seems that minimal invasive techniques, like percutaneous iliosacral fixation, are good options and for spinopelvic dissociation, spinopelvic fixation is the treatment of choice, with reasonable outcome.

Authors' Contributions

Babak Mirzashahi: corresponding author; Mahmoud Farzan: supervise the authors; Mirmostafa Sadat: technical supervision; Mohamad Zarei: data collection; Parviz Habibollahzade: technical and scientific aspect

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