Percutaneous Screw Fixation of Crescent Fracture-Dislocation of the Sacroiliac Joint

XIAOLONG SHUI, MD; XIAOZHO YING, MS; CHUANWAN MAO, BS; YONGZENG FENG, MD; LINWEI CHEN, MD; JIANZHONG KONG, BS; XIAOSHAN GUO, BS; GANG WANG, MD

abstract

Crescent fracture-dislocation of the sacroiliac joint (CFDSIJ) is a type of lateral compression pelvic injury associated with instability. Open reduction and internal fixation is a traditional treatment of CFDSIJ. However, a minimally invasive method has never been reported. The purpose of this study was to assess the outcome of closed reduction and percutaneous fixation for different types of CFDSIJ and present their clinical outcome. The authors reviewed 117 patients diagnosed with CFDSIJ between July 2003 and July 2013. Closed reduction and percutaneous fixation was performed in 73 patients. Treatment selection was based on Day’s fracture classification. For type I fractures, fixation perpendicular to the fracture line were performed. For type II fractures, crossed fixation was performed. For type III fractures, fixation was performed with iliosacral screws. Forty-four patients were treated by open reduction and plate fixation. Demographics, fracture pattern distribution, blood loss, incision lengths, revision surgeries, radiological results, and functional scores were compared. All 117 patients were followed for more than 6 months (mean, 14 months [range, 6-24 months]). Blood loss, extensive exposure, duration of posterior ring surgery, duration of hospital stay, and infection rates were lower in the closed group \( (P<.01) \). Patients in the closed group achieved better functional performance \( (P<.01) \). There were no significant differences in reduction quality \( (P=.32) \), revision surgery rates \( (P=.27) \), and iatrogenic neurologic injuries \( (P=.2) \) between the 2 groups. The authors’ results indicate that closed reduction and percutaneous fixation is a safe and effective surgical method for CFDSIJ. [Orthopedics. 2015; 38(11):e976-e982.]

The authors are from the Department of Orthopaedic Trauma (XS, GW), Nanfang Hospital, Southern Medical University, Guangzhou; the Department of Orthopaedic Surgery (XS, XY, YF, JK, XG) and the Department of Radiology (CM), The Second Affiliated Hospital of Wenzhou Medical University, Wenzhou; and the Department of Orthopaedic Surgery (LC), Second Affiliated Hospital, School of Medicine, Zhejiang University, Hangzhou, China.

The authors have no relevant financial relationships to disclose.

Correspondence should be addressed to: Gang Wang, MD, Department of Orthopaedic Trauma, Nanfang Hospital, Southern Medical University, 1838 Guangzhou Rd, Guangzhou 510000, China (13616634588@163.com).

Received: November 9, 2014; Accepted: April 8, 2015.

doi: 10.3928/01477447-20151020-05
Pelvic ring injuries are classified into 3 main groups in the Young-Burgess classification system: anteroposterior compression, lateral compression, and vertical shear fractures. Lateral compression injuries represent more than 50% of all pelvic ring injuries and lead to a rotationally unstable hemipelvis. A subtype of lateral compression injury, crescent fracture-dislocation of the sacroiliac joint (CFDSIJ), which accounts for approximately 12% of pelvic ring injuries, was originally defined as a fracture-dislocation of the sacroiliac joint. It is associated with various injuries of the sacroiliac ligament complex, extending to a posterior ilium as a crescent fracture, which is still attached to the sacrum with the ligament complex of the posterior sacroiliac joint. Crescent fracture-dislocation of the sacroiliac joint is often associated with pubic symphysis injury or pubic rami fracture in the anterior pelvic ring. Borrelli et al first reported CFDSIJ and introduced open reduction and internal fixation (ORIF) through a postero-lateral approach.

Day et al divided CFDSIJ into 3 main types: type I fractures involve less than one-third of the sacroiliac (SI) joint, resulting in a large and stable fragment of the posterior crescent-shaped ilium; type II fractures involve one-third of the SI joint, resulting in a moderate and stable fragment; and type III fractures involve more than one-third of the SI joint, resulting in a small and stable fragment. On the basis of this classification, Day et al proposed the principle of surgical treatments for different types of fractures: ORIF through an ilioinguinal approach for type I fractures, ORIF through a posterior surgical approach for type II fractures, and closed or open reduction and iliosacral screw fixation for type III fractures.

Open reduction and internal fixation is the preference in most cases of CFDSIJ, especially types I and II. It is well known that pelvic injuries are often associated with multiple injuries and hemodynamic instability. However, heavy blood loss, nerve injury, and incision infection are inevitable in ORIF. Closed reduction and percutaneous iliosacral screw fixation has not been previously reported. The current authors recommend closed reduction and percutaneous screw fixation for all CFDSIJ types. The authors compared this technique with traditional ORIF in the treatment of CFDSIJ. Long-term radiological and functional outcomes were compared. Special attention was paid to loss of reduction, infection, late symptoms, and functional recovery.

**Materials and Methods**

This study is a retrospective review of the cases of CFDSIJ performed between July 2003 and July 2013. The study received institutional review board approval, and informed consent was received from all patients. All patients were treated at 1 of 2 Level I regional trauma centers. One hundred twenty-two patients met the following inclusion criteria: (1) patients without known local or systemic infection; (2) patients with no medical contraindication (severe vascular or neurologic injury, diabetes mellitus); (3) skeletally mature patients; and (4) patients with an unstable pelvic injury undergoing internal fixation.

Demographics (age and sex), fracture classification (Tile6 and Day5 classifications), Injury Severity Score (ISS),10 and associated injuries were extracted from the database. Five patients were lost to follow-up, leaving 117 patients who participated in clinical follow-up at a mean of 14 months (range, 6-24 months). Seventy-three fractures underwent closed reduction and percutaneous screw fixation (group 1), and 44 underwent ORIF (group 2). Patients in the 2 groups were well matched for age, sex, and fracture classification.

**Management Protocol**

Eight patients with open pelvic injuries and associated abdominal organ injuries underwent emergent surgery. Mean time from injury to surgery was 3.4 days (range, 0-8 days). Preoperative traction was generally performed to correct vertical dislocation of the posterior ring, which was one of the important signs the authors required for closed reduction and percutaneous fixation.

**Surgical Technique**

In group 1, closed reduction of fractures was a crucial step. In patients with displaced rami fracture or pubic symphysis dislocation, closed reduction and screw fixation in the anterior ring was performed first. External rotation of the injured side of the pelvis was performed to reduce the lateral displacement, which can be done by pushing the ilium outward through manipulation of the iliac crest or by externally rotating the ilium with a 5-mm Schanz nail embedded in the ilium as a handle. Longitudinal traction of the lower extremities was implemented to reduce the vertical dislocation. If closed reduction failed, a 5-mm incision was made at the apex of the fracture and dislocation intraoperatively. A contact pin was used to push the proximal dislocated part of the posterior ilium toward the distal end, supplemented by longitudinal traction of the lower extremities.

After successful closed reduction, fixation perpendicular to the fracture line was performed with several parallel iliac screws for type I fractures. The screw direction was from the anterior inferior iliac spine to the posterior superior iliac spine in the supine position, or vice versa in the prone position (referred to as “posterior iliac screws”) (Figure 1). For type II fractures, crossed fixation was performed with several posterior iliac screws and iliosacral screws in the prone position. Reduction and fixation of SI joint dislocation with sacroiliac screws was performed first, followed by fixation with posterior iliac screws (Figure 2). For type III fractures, fixation was performed with several percutaneous iliosacral screws (Figure 3). Methods of percutaneous screw fixation
When placing closed iliac screws from the anterior inferior iliac spine to the posterior superior iliac spine, the entry point should be at the center of the teardrop when placing the needle at the outlet of the obturator, 2 cm away from the acetabular articular surface, to avoid invasion into the joint cavity. During this process, repeated fluoroscopic examination on the iliac oblique view should be performed to ensure the guide pin approaches the superior greater sciatic notch. When placing closed iliac screws posteriorly, the entry point near the central line of the posterior superior iliac spine is identified via fluoroscopic examination after reduction, with the guide pin pointing to the anterior inferior iliac spine during anteroposterior fluoroscopic examination. The guide pin is inserted 15° outwardly in the transverse plane and 30° downwardly in the sagittal plane. Repeated fluoroscopic examination should be performed to ensure the guide pin inserts above the greater sciatic notch. A second guide pin can be inserted 1 to 2 cm away from the first one.

In group 2, all surgical procedures were performed through either a posterolateral approach or an ilioinguinal approach. The patients in group 2 underwent ORIF using 1 to 2 pelvic reconstruction plates (Stryker, Mahwah, New Jersey), which varied in length. Anterior reduction and fixation was mandatory in cases with significantly displaced anterior ring fracture and dislocation.

**Outcome Evaluation**

Radiographs were obtained before primary treatment, after fixation, and at final follow-up. The radiological result was graded by the maximal residual displacement in the posterior or anterior injury to the pelvic ring (excellent, 0-4 mm; good, 5-10 mm; fair, 11-20 mm; poor, >20 mm). Functional outcome was measured using the scoring system described by Majeed, which is based on the clini-
cal findings of pain, sitting, sexual intercourse, walking, and work.

**Statistical Analysis**

Statistical analyses were performed using Student’s *t* test, Fisher’s exact test, and Wilcoxon rank-sum test. A *P* value of .05 was considered significant.

**RESULTS**

Demographic and injury severity data were not different in the 2 groups with regard to age, sex, ISS, fracture characteristics, open fracture, and associated injury (*P >.05*) (Table 1).

Surgical procedures and fixation methods were compared between the 2 groups. In group 1, closed reduction and percutaneous screw fixation was performed for anterior ring injury in 54 patients, and ORIF was performed in 7 patients; for another 12 patients, internal fixation was not performed due to insignificant fracture and dislocation. In group 2, open reduction and plate internal fixation was performed for significant displace anterior ring injury in 29 patients. The difference of anterior fixation was not significant (*P* = .57). There were significant differences in the duration of posterior ring surgery between the 2 groups. Mean operative time was 38 minutes (range, 25-55 minutes) for closed reduction and percutaneous fixation and 69 minutes (range, 45-105 minutes) for ORIF.

Mean intraoperative and postoperative blood loss in group 1 (23±3 mL) was much less than that in group 2 (186±19 mL) (*P <.01*). Mean incision length of the posterior wound in group 1 (1.9±0.8 cm) was shorter than that in group 2 (10.1±1.3 cm) (*P <.01*). Mean hospital stay in group 1 (5.2±1.4 days) was much shorter than that in group 2 (9±2.3 days) (*P <.01*) (Table 2). Mean displacement remaining postoperatively was 4.2±1.8 mm in group 1 and 3.6±1.1 mm in group 2. Reduction quality was comparable between the 2 groups (*P >.05*) (Table 3).

Postoperative infections or incision problems were observed in 2 patients in group 1 and 8 patients in group 2. The infection rate in group 1 was significantly lower than that in group 2 (*P <.05*). Patients recovered after treatment consisting of dressing changes and antibiotics. Two patients in group 1 and 3 patients in group 2 experienced redislocation of the SI joint and recurrent pain during postoperative follow-up. These 5 patients underwent revision surgery. Reoperation rates between the 2 groups were not significantly different (*P = .27*). Iatrogenic neurologic injuries were observed in 2 (12.2%) patients in group 1 and 3 (19%) patients in group 2. Massive vascular damage was not seen in either group. The rates of neurologic injury were not significantly different between the 2 groups (*P = .39*) (Table 4).

**Table 1**

<table>
<thead>
<tr>
<th>Patient and Fracture Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variable</strong></td>
</tr>
<tr>
<td><strong>Age, mean±SD, y</strong></td>
</tr>
<tr>
<td><strong>Sex, No.</strong></td>
</tr>
<tr>
<td><strong>ISS, mean±SD</strong></td>
</tr>
<tr>
<td><strong>Bone, No.</strong></td>
</tr>
<tr>
<td><strong>Day type, No.</strong></td>
</tr>
<tr>
<td><strong>Open fracture, No.</strong></td>
</tr>
<tr>
<td><strong>Associated injury, No.</strong></td>
</tr>
</tbody>
</table>

*Abbreviation: ISS, Injury Severity Score.*

*Closed reduction and percutaneous screw fixation.*

*Open reduction and internal fixation.*

*Student’s *t* test.*

*Fisher’s exact test.*

**Table 2**

<table>
<thead>
<tr>
<th>Surgical Data and Fixation Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variable</strong></td>
</tr>
<tr>
<td><strong>Time to surgery, mean±SD, d</strong></td>
</tr>
<tr>
<td><strong>Anterior fixation, No.</strong></td>
</tr>
<tr>
<td><strong>Operative time, mean±SD, min</strong></td>
</tr>
<tr>
<td><strong>Blood loss, mean±SD, mL</strong></td>
</tr>
<tr>
<td><strong>Incision length, mean±SD, cm</strong></td>
</tr>
<tr>
<td><strong>Hospital stay, mean±SD, d</strong></td>
</tr>
</tbody>
</table>

*Closed reduction and percutaneous screw fixation.*

*Open reduction and internal fixation.*

*Student’s *t* test.*

*Fisher’s exact test.*
The radiological outcomes after fracture healing were compared between the 2 groups (Table 5). Mean displacement at final follow-up was 6.5±1.6 mm in group 1 and 8.3±2.7 mm in group 2 (P=.12). The functional outcomes showed that functional recovery was better in group 1 than in group 2 (P<.01) (Table 6). Mean functional score was 86±17 in group 1 and 81±19 in group 2.

**Discussion**

Crescent fracture-dislocation of the sacroiliac joint is a relatively uncommon type of lateral compression injury. The main purpose of surgical intervention is to achieve early reduction and fixation of the associated fracture or dislocation of the pelvic ring. This treatment can facilitate early mobilization and reduce disabilities caused by posterior traumatic nonunion, osteoarthritis, or instability of the SI joint. A number of surgical techniques have been described for the reduction and fixation of SI fracture dislocations. Day et al described the CFDSIJ classification system based on the extent and location of SI joint involvement. For type I and II fractures, open reduction and plate fixation is the preferred choice. For type III injuries, fixation with iliosacral screws is performed.

In recent years, tremendous progress has been made with the percutaneous technique for pelvic fractures. Repair of SI joint dislocation and sacral fracture using percutaneous iliosacral screw insertion has been described. Day et al described the CFDSIJ classification system based on the extent and location of SI joint involvement. For type I and II fractures, open reduction and plate fixation is the preferred choice. For type III injuries, fixation with iliosacral screws is performed.

For type I fractures, percutaneous fixation is performed with 1 to 2 iliac screws from the anterior inferior iliac spine to the posterior superior iliac spine or from the posterior superior iliac spine to the anterior inferior iliac spine. Anatomical and imaging studies suggest that the iliac bone is thicker in the posterior superior iliac spine than in the anterior inferior iliac spine, which can accommodate 1 to 2 six- to eight-mm screws. Clinical findings suggested that the fracture line in the large posterior crescent iliac is often perpendicular to the line linking the posterior superior iliac spine to the anterior inferior iliac spine. Therefore, fixation with cannulated screws in this type of fracture can be perpendicular to the fracture line. Simonian and Routt reported satisfactory biomechanical results with this fixation.

For type II fractures, because crescent fractures are relatively large, the current authors used crossed fixation with iliosacral screws and posterior iliac screws. After correcting the vertical dislocation,
reduction and fixation with iliosacral screws for SI joint dislocation should be performed before posterior iliac screw fixation because iliac fracture fixation could interfere with SI joint reduction. Similar to Day et al, percussive iliosacral screw fixation was used in the majority of type III fractures.

Preoperative heavy-weight (10-20 kg) traction is important for closed reduction and internal fixation for CFDSIJ. In cases where reduction cannot be achieved preoperatively, reduction can be performed by introducing a contact pin percutaneously above the fracture-dislocation line of the posterior iliac spine, supplemented by vertical traction in the lower extremities.

Before fixation for fracture-dislocation of the posterior pelvic ring, reduction and fixation of the anterior pelvic ring are also important. Biomechanical experiments by Simonian and Routt suggested that simultaneous fixation of the anterior and posterior pelvic rings could make the pelvic ring a geometrically unchangeable system. Furthermore, many injuries were featured by pelvic rotation dislocation in horizontal, sagittal, and coronal planes. Reduction and fixation for anterior pelvic ring in supine position could help with correcting rotation dislocation. Therefore, reduction and fixation of the anterior pelvic ring could be essential for closed reduction of CFDSIJ.

Insertion of iliac screws from the anterior inferior iliac spine to the posterior superior iliac spine in the supine position has been reported. The current authors advocate changing the direction from the posterior superior iliac spine to the anterior inferior iliac spine. This technique has several advantages, including more obvious landmarks on the posterior superior iliac spine and, because posterior iliac fractures are located posteriorly, screw length when introduced posteriorly is shorter than when introduced anteroposteriorly, decreasing the possibility of piercing the iliac cortex and providing more reliable fixation.

This study has several limitations. First, the cases enrolled in this study were from the retrospective review of a surgeon in a medical institute. Second, follow-up time was relatively short (mean, 14 months [range, 6-24 months]). Long-term outcomes remain to be investigated. Finally, further biomechanical tests must be implemented to verify the stability of screw fixation.

**CONCLUSION**
Crescent fracture-dislocations of the sacroiliac joint account for approximately 12% of pelvic ring injuries. Closed reduction and percutaneous fixation can be performed in all types of these fractures, playing a vital role in the treatment of pelvic ring fractures. The current authors compared closed reduction and percutaneous fixation with ORIF in the treatment of CFDSIJ. In this study, there was a similar distribution of demographic and injury severity data between the 2 groups. Patients treated with closed reduction and percutaneous screw fixation had a lower rate of iatrogenic injuries, such as blood loss and extensive exposure, than those who underwent ORIF. The percutaneous surgical procedure could simplify the treatment of pelvic ring fractures and avoid massive blood loss and incision complications. In patients with multiple trauma and hemodynamic instability, percutaneous fixation could increase survival. Compared with patients in the ORIF group, all patients in the closed reduction group achieved satisfactory radiological results and functional outcomes.

**REFERENCES**

---

**Table 6**

<table>
<thead>
<tr>
<th>Group</th>
<th>Excellent (&gt;85)</th>
<th>Good (70-84)</th>
<th>Fair (55-69)</th>
<th>Poor (&lt;55)</th>
<th>α</th>
</tr>
</thead>
<tbody>
<tr>
<td>1b</td>
<td>35</td>
<td>28</td>
<td>8</td>
<td>2</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>2c</td>
<td>13</td>
<td>11</td>
<td>16</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

*According to Majeed.12
bClosed reduction and percutaneous screw fixation.
cOpen reduction and internal fixation.
αWilcoxon rank-sum test.


