

**RESEARCH ARTICLE**

# Clinical Results of Percutaneous Fixation of Pelvic and Acetabular Fractures: A Minimally Invasive Internal Fixation Technique

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**Abstract**

**Background:** The pelvic ring fractures (PRF) and acetabular fractures (AF) are among the major orthopedic injuries associated with high rates of morbidity and mortality. Open surgical stabilization is the standard treatment for the majority of these complications. Percutaneous minimally invasive surgical stabilization of the fractures has become an accepted treatment method for the past several years. This study investigated the outcomes of percutaneous fixation of pelvic and acetabular fractures.

**Methods:** Totally, 143 patients with PRF or AF of whom 95 cases were males underwent percutaneous fixation between February 2015 and September 2016. All the operations were performed by a single surgeon in a supine position and under C-arm fluoroscopy visualization. The patients were followed up for one year.

**Results:** All the fractures healed in all of the patients within the first postoperative three months. The patients could bear weight completely on both lower limbs. Out of 143 patients, 133 cases could get back to their preoperative work (93%). The mean amount of intraoperative blood loss was  $29 \pm 19$  cc. Of the total patients, seven cases required oral analgesics because of moderate pain (4.9%). The means of operation time and length of incision were  $32 \pm 8$  min and  $3.2 \pm 2.4$  cm, respectively. There was one screw back out and one deep infection. No neurovascular injury was reported in this study.

**Conclusion:** Closed reduction and percutaneous minimally invasive screw fixation for a pelvic ring or acetabular fractures is a useful surgical treatment option with low complication rates.

**Level of evidence:** IV

**Keywords:** Acetabulum, Fracture, Internal fixation, Minimally invasive surgery, Pelvis, Percutaneous screw fixation

**Introduction**

Pelvic ring and acetabular fractures are associated with a high risk of morbidity and mortality due to the substantial hemorrhage and injury to the internal organs (1, 2). Treatment of these fractures remains challenging and represents a major

dilemma for most of the orthopedic surgeons. The epidemiological data regarding these injuries were rarely obtained in the literature. The incidence rate of acetabular fracture (AF) is within the range of 0.5%-8% (3). Moreover, there were 24059 patients with

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unstable pelvic ring fractures (PRF) in the United States with an in-hospital mortality rate of 8.3% between 2000 and 2009 (2).

It has been shown that early surgical fixation of PRF and AF is the treatment of choice due to several advantages, such as early ambulation, and reduced morbidity as well as mortality (4,5). However, the optimal method of fixation, especially in unstable fractures, remains controversial (1). Open reduction internal fixation (ORIF) requires extensive exposure with a high risk of several intra- and postoperative complications, including massive hemorrhage, deep venous thrombosis, neurovascular injuries, heterotopic ossification (HO), and infection (6-8).

After the introduction of closed reduction using percutaneous screw fixation by Routt et al. (9), several authors have used this minimally invasive technique for the treatment of patients with PRF and AF (10-17). The mentioned advantages for percutaneous screw fixation of pelvic and acetabular fractures in these studies include less soft tissue injury, less blood loss, and a lower rate of infection.

Furthermore, early weight bearing ambulation will be possible with percutaneous screw fixation (12, 18). However, the technique may be associated with some complications, such as the increased risk of neurovascular injuries, internal organ injuries, screw misplacement, and screw fracture (5, 13, 14, 17, 19-23).

A systematic review has been recently demonstrated a dearth of evidence to determine the efficiency of PRF and AF fixation methods. Further research is needed regarding closed or open reduction (24). Therefore, the present study investigated the clinical and radiological outcomes and complications of percutaneous screw fixation of PRF and AF. To the best of our knowledge, there is only one previous report utilizing this technique in Iran. This study was also employed the same technique with more patients.

### Materials and Methods

The study protocol was approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences. In total, 212 patients with PRF and AF who were candidates to percutaneous screw fixation were enrolled in the current study between February 2015 and September 2016. The definitive diagnosis of PRF and AF was based on clinical suspicion and confirmation using x-rays and computed tomography (CT) scanning. The PRFs and AFs were classified based on Young-Burgess classification and Judet as well as Letournel classification, respectively. Written informed consent was obtained from patients or their parents.

The inclusion criteria in this study were PRF or AF indicated percutaneous screw fixation included fractures of the pubic rami, vertical fractures of the sacrum, crescent fractures and sacroiliac fracture with and without dislocation and all anterior column, and transverse as well as both column fractures of the acetabulum. Out of 212 patients, 61 cases were excluded from the study due to the hemodynamic instability or definite indication of ORIF.

Based on the fracture site and age of the patients, the indication for closed reduction and percutaneous screw fixation included cases with acetabular fractures who had no displacement when they were younger than 60 years and no displacement or minimal displacement (<5mm) when they were older than 60 years. Moreover, those with pelvic ring fracture less than 2 cm of displacement were indicated eligible for the fixation. All of the patients were operated by the same surgeon with closed reduction and percutaneous screw fixation under the fluoroscopy visualization.

All of the surgeries were performed under spinal anesthesia. Closed reduction of PRFs was achieved using traction with or without a fracture table. With regard to AFs, a long retractor was inserted through a small incision made on different sites (based on the location of the fracture) to reduce the fracture. The reduction was controlled intraoperatively using classic radiographic views, including anteroposterior, obturator oblique, iliac oblique and inlet, and outlet pelvic views. A guide pin was inserted and if appropriate, cannulated drilling was performed followed by screw placement. In this study, 6.5 mm partially threaded cannulated screws were used for fixation.

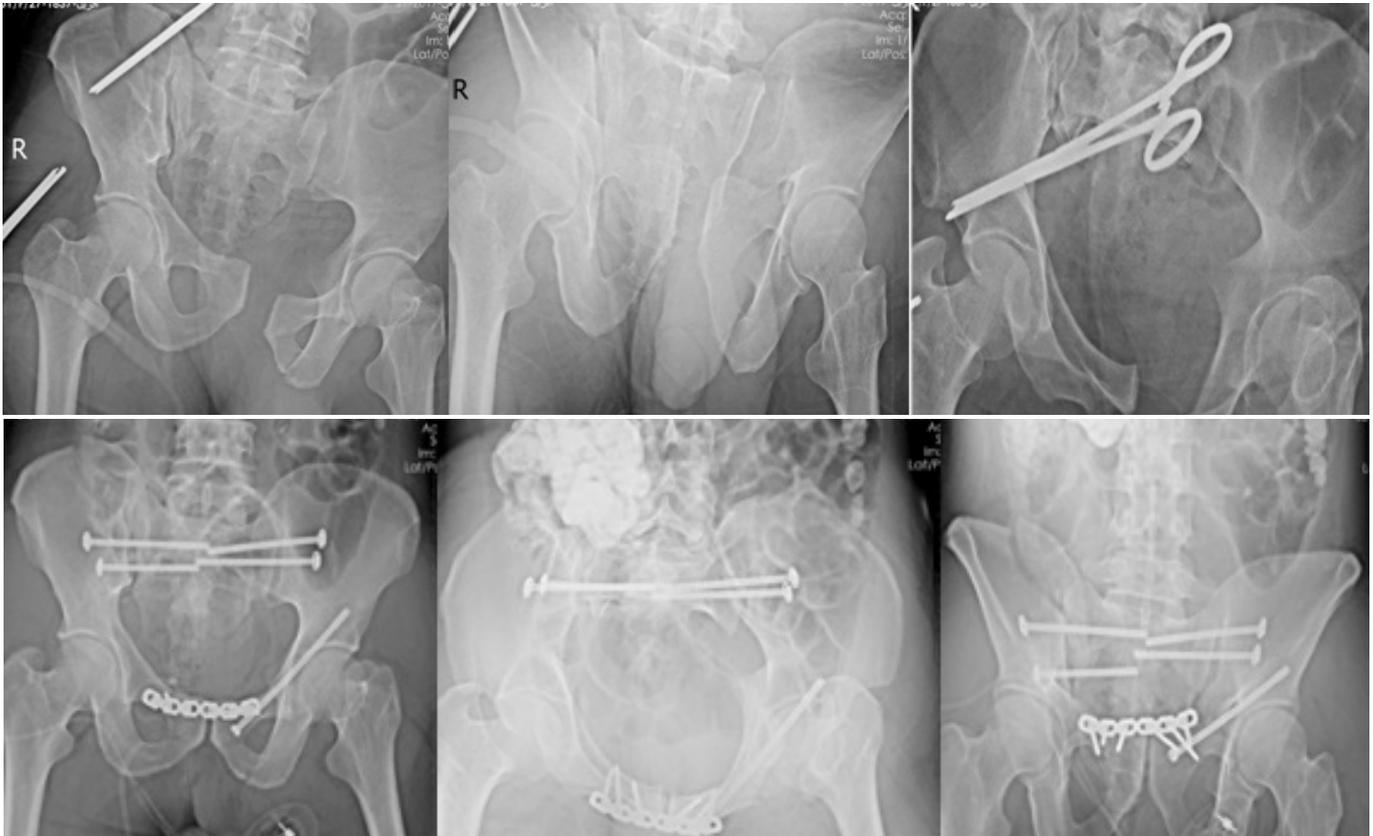
Different screws utilized in this study included anterior column screw (antegrade or retrograde), posterior column screw (antegrade or retrograde), LC2 screw (antegrade or retrograde), sacroiliac screw, and transiliac screw [Figure 1]. All of the operations were performed in the supine position. After fixation, the stability was controlled using under-stress fluoroscopy. All of the patients received a postoperative intravenous antibiotic for 24 h and low molecular-weight heparin for at least one week (1 to 6 weeks).

All classic radiographic views were obtained postoperatively [Figure 2]. Within the first to third postoperative day, partial weight bearing or tolerated weight bearing was initiated based on the patients' general condition and type of the injuries. The views were repeated after 6 weeks, 3, 6, and 12 months postoperatively. The measured variables included the size of the incision, operation time, the time span from surgery to first walking, pain intensity at the last visit, the union of the fracture, the amount of intraoperative blood loss, and the presence of nerve injury.

The operation time was measured from the first fluoroscopic exposure after patient positioning until the last suture. The pain intensity was measured utilizing a visual analog scale (VAS). In this setting, 0 and 10 indicated no pain and the most severe imaginable pain, respectively. The volume of blood loss was measured based on the difference between the weight of dry and bloody gauzes. Since multiple stab incisions were to insert multiple screws, the length of the incision was calculated as the sum of the length of all incisions.

### Results

Out of 151 patients, 8 cases were lost to follow up and the study was completed with 143 patients. Table 1 summarizes the patients' characteristics. Different types of screw placement used for percutaneous fixation is



**Figure 1. a)** Preoperative views of a 34-year-old male with a bilateral anteroposterior compression fracture. Left sacroiliac joint dislocation, right sacroiliac joint fracture dislocation, ramus fracture, and pubic symphysis diastasis are visible. **b)** Postoperative views showing Bilateral S1 and S2 sacroiliac screws were inserted for the treatment of sacroiliac joints injuries. The superior ramus fracture was stabilized using a retrograde superior ramus screw. The pubic symphysis diastasis was reduced and fixated using a reconstruction plate.

shown in Table 2. One should note that it was required to utilize more than one type of screw fixation in some patients. In 23 patients, the closed fracture reduction was performed through a small incision. Furthermore, 20 patients were in need of simultaneous open reduction and internal fixation for pubic symphysis diastasis.

The mean values of blood loss volume, operation time, and incision length are shown in Table 3. During the operation, the measured blood loss was less than 30 ml in all of the patients except those who needed percutaneous manipulation. The blood loss was approximately 100 ml in these cases.

Partial weight bearing or weight bearing as tolerated was initiated according to the type of the fracture at the first postoperative day for 93 patients. The others started partial weight bearing ambulation at the third postoperative day due to the comorbidities or concomitant fractures. All of the fractures were united on the x-rays taken at three months postoperatively. At the last visit, all patients could ambulate with full weight bearing. In total, 24 patients felt slight pain at the fracture site (16.8%); however, only seven patients required oral analgesic consumption (4.9%). Based on

VAS pain intensity, 133 patients (93%) got back to their preoperative activities while 10 cases had to change their job due to the quality of their occupation.

The major complications were one screw back out and one deep wound infection. The back out screw was removed and the fracture continued to the union by weight-bearing restriction. The infection was treated by surgical debridement and intravenous antibiotics. No postoperative neurologic deficit was reported in this study.

### Discussion

The most important finding of the current study was the significant effect of different types of PRF and/or AF treatment using percutaneous screw fixation on the excellent clinical and radiological outcomes without increased risk of neurovascular injuries.

There are several internal fixation techniques for PRF and AF. In most of these injuries, ORIF, including anterior and posterior plating, trans-sacral bars, and tension band plating is accepted as the standard method (16, 25, 26). However, high risk of intra- and postoperative complications, such as massive blood loss, infection, and



**Figure 2.** A 45-year-old female with right sacral fracture (Dennis type II), right superior ramus fracture, and left transverse acetabular fracture. Two transsacral screws were inserted in addition to bilateral superior ramus screws. a) Preoperative x-rays and b) Postoperative x-rays.

HO remains concerned (6-8).

These problems propelled surgeons to look for minimally invasive techniques leading to decreased soft tissue trauma and blood loss, as well as some other advantages. Percutaneous screw fixation of PRF was originally described by Routt et al. in 1993 (9).

Currently, percutaneous screw fixation of PRF and AF is increasingly used worldwide with promising outcomes (10-17). However, since this method has not got popularity among Iranian orthopedic surgeons, it was introduced to the patients as a versatile and practical technique without significant complications.

Given that this technique uses intramedullary screws, the rigidity of the fixation would be so high

that the patient can bear weight on the day after the surgery (18). This is a major advantage of this method, compared to open methods and plate fixation, which usually need a prolonged duration of limited weight bearing. In a recent finite element analysis, Lee et al. showed that fixation of sacroiliac joint injuries using posterior iliosacral screw was more stable and associated with a lower risk of implant failure and pelvic breakage, compared to the sacral bar or locking compression plate (27).

In the current study, partial weight bearing was initiated at the first postoperative day in 65% of the patients and all of the patients could ambulate with partial weight bearing at the third postoperative day.

| Table 1. Characteristics of the patients with *PRF and or *AF treated using percutaneous screw placement |                                |              |            |
|--|--------------------------------|--------------|------------|
| <b>No.</b>   | 143                            |              |            |
| <b>Gender</b>  | Male                           | 95 (66.5%)   |            |
|  | Female                         | 48 (33.5%)   |            |
| <b>Age (y)</b>   | 29+7(16-65)                    |              |            |
| <b>Mechanism of injury</b>   | Car accident                   | 87 (60.8%)   |            |
|  | Falling from a height          | 56 (39.2%)   |            |
| <b>Mechanisms of fracture</b>  | LC                             | 41 (28.7%)   |            |
|  | LC+acetabular ant. column fx.  | 27 (18.9%)   |            |
|  | Combined LC and VS             | 8 (5.6%)     |            |
|  | APC                            | 29 (20.3%)   |            |
|  | APC+acetabular ant. column fx. | 7            |            |
|  | Isolated AF                    | 31 (21.7%)   | Transverse |
|  |                                | Both columns | 3          |
| <b>Duration of hospital admission (d)</b>  | 4±2 (1-10)                     |              |            |

PRF: Pelvic ring fracture; AF: Acetabular fracture; LC: Lateral compression; ant: Anterior; fx: fracture; VS: Vertical shear; APC: Anteroposterior compression

**Table 2. Different types of percutaneous screw placement in patients with \*PRF and or \*AF**

|  |    |
|--|----|
| <b>Iliosacral or transsacral screw</b> | 93 |
| <b>Iliopubic screw</b>                 | 63 |
| <b>LC2 screw</b>                       | 20 |
| <b>Posterior column screw</b>          | 8  |
| <b>Bilateral iliopubic screws</b>      | 23 |
| <b>Bilateral iliosacral screws</b>     | 10 |

\* PRF: Pelvic ring fracture

\* AF: Acetabular fracture

However, percutaneous screw fixation of PRF and/or AF has its own problems. The screw placement is technically demanding due to the complicated anatomical features of the pelvis and acetabulum and narrow osseous corridors (12).

Furthermore, some complications, such as osteoarthritis, neurovascular injuries (radiculopathy, lateral femoral cutaneous nerve injury, sciatic nerve injury, and femoral nerve injury), misplacement of the screws, and screw loosening were reported when PRF and/or AF was fixated using percutaneous screw placement (5, 13, 14, 17, 23). For instance, the rates of iatrogenic nerve injury and hardware failure were reported 0-7.2% and 0-2.9%, respectively, using different methods, techniques, and modalities (5, 13, 17).

Schweritz et al. reported the results of percutaneous iliosacral screw insertion in 71 patients with unstable pelvic fractures. After 31 months of follow-up, 61

**Table 3. The mean of blood loss volume, operation time, and length of the incision**

|                                    |                |
|------------------------------------|----------------|
| <b>Blood loss volume (cc)</b>      | 29±19 (18-96)  |
| <b>Operation time (min)</b>        | 32±8 (72-22)   |
| <b>Length of the incision (cm)</b> | 3.2±2.4 (1-10) |

patients (86%) could return to their preoperative activities and work. Furthermore, they reported excellent results in 66 patients regarding their last follow-up. However, postoperative neurologic deficit and sacroiliac osteoarthritis occurred in 2 (2.8%) and 15 (21.1%) patients, respectively, regarding long-term follow-up (5).

In a study conducted by Tempelaere et al., the outcomes of percutaneous posterior fixation of pelvic ring fractures were evaluated in 11 patients after 4 years. The radiological and functional results were good to excellent without intraoperative complications (17).

In the current study, all of the fractures were united within the first postoperative three months. Furthermore, most of the patients could return to their pre-injury work (93%). Moreover, there was no thromboembolic event, HO, or neurovascular injury in the current study. The total rate of postoperative complications was 1.4%. Additionally, no screw breakage was observed in the current study, except for the occurrence of one screw failure. The obtained results are promising and demonstrate that minimally invasive percutaneous screw fixation is a safe procedure and efficient for patients with PRF and/or AF.

The mean pain intensity was about 2.7 after 6 months in a study by Chui et al. (13) which was consistent with the findings of this study in which the mean VAS was 2.2 after one year. In the study conducted by Fang et al., 10.3% of the patients suffered from chronic pain after the operation (23). However, 16.8% of the patients reported a mild to moderate pain in the fracture site in the current study, and 4.9% of cases required analgesic consumption.

The volume of intraoperative blood loss was not considered and there was no need to blood transfusion in this study. The mean values of blood loss volume and operation time were 29 cc and 32 min, respectively, in the present study. Clearly, less blood loss is associated with the better general condition of the patients after the operation and eliminates the concerns regarding the complications and costs of the blood transfusion. In addition, the shorter the operation time, the more decreased the rate of infection.

According to a study by Chui et al., a considerably larger amount of blood loss (179 ml) and longer operation time (141 min) were reported, compared to those in the current study. It seems remarkable since they employed a 3D navigation system for the operations (13). The mean operation time was 63 min in the study by Eckardt et al. (14). Moreover, the mean operation time in the study performed by Tempelaere et al. was 45 min which was closer to the findings in the current study (17).

The inconsistencies in some measures in the above-mentioned studies result from differences in age of the patients and patient selection, especially the type of fractures. Furthermore, the utilization of different techniques and modalities can affect the measures significantly. It should be noted that percutaneous screw placement is technically demanding and has a learning curve. With more expertise, the surgeon will be able to place the screws more precisely and quickly. In addition, as shown in the current study, there was no neurovascular

injury using advanced modalities due to the surgeon's skill and expertise.

Although this study paved the way on the utilization of percutaneous fixation on pelvic and acetabular fractures, it suffers from some limitations. The current study was a case series and the outcomes were not compared with those in ORIF. All of the patients with pelvic and acetabular fractures amenable to this method of fixation were included in the current study. Furthermore, the reduction of the fracture was evaluated using plain radiography rather than CT scanning. In addition, it seems that long-term follow-ups are necessary to find more reliable outcomes. As a result, it was not possible to investigate the presence of degenerative changes in the current study due to the short-term follow-up.

Closed reduction and percutaneous minimally invasive screw fixation is a reliable treatment method for the pelvic ring and acetabular fractures with minimal morbidity and complication rate. This intramedullary fixation is the most rigid fixation method in the pelvic ring that helps the patient bear early postoperative weight.

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