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Case Report

Fixation of unstable pelvic fractures with minimally invasive adjustable plate

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Abstract: *Objective:* Unstable pelvic fractures are relatively rare injuries usually requiring reduction and internal fixation. Selecting appropriate methods for unstable pelvic fractures remains a challenging problem for orthopaedic surgeons. The aim of this study was to present the techniques and outcomes of MIAP for unstable pelvic fractures. *Methods:* We performed a retrospective analysis of patients with unstable pelvic ring fractures treated with minimally invasive adjustable plate at a level I trauma centre. Outcome evaluation was assessed using Majeed score standard, duration of surgery, blood loss, radiation exposure and size of incision. *Results:* Twenty-one patients were available for follow-up after at least 12 months. The main findings were as follows: the average duration of surgery was 67.5 min, the intraoperative blood loss was 204 ml on average, the average radiation exposure was 8 s, and the size of incision was 8.8 cm on average. The mean Majeed functional evaluation score was 85.3 points. *Conclusion:* Minimally invasive adjustable plate may be a good alternative for treating unstable pelvic fractures. It has the advantages of technically safe, minimally invasive, less radiation exposure and time saving.

Keywords: Unstable pelvic fractures, fracture fixation, internal, minimally invasive adjustable plate

Introduction

Pelvic fractures are relatively small rare injury, accounting for 3.64% of fractures in adults [1], and 68.3% of pelvic fractures are unstable fractures, which are serious injuries. They usually results from high-energy trauma, such as falls and motor vehicle accidents. In contrast to the low incidence of these injuries, the high mortality rate is 5-20% [2-4]. Selecting appropriate methods for unstable pelvic fractures remains a challenging problem for orthopaedic surgeons. The stability of the pelvis is mainly related to the integrity of posterior pelvic ring [5]. Therefore, the treatment for unstable pelvic fractures needs to restore the continuity and stability of posterior pelvic ring as far as possible. Greater stability of posterior pelvic ring can be achieved by internal fixation [6]. There are many kinds of methods available, including iliosacral (IS) screw, tension band plate (TBP), triangular osteosynthesis and so on. IS screw fixation is a safe alternative to open fixation, with reported satisfactory results and lower rates of bleeding and infection [7-9]. However, this technique requires continuous fluoroscopic or computerized tomography guidance for appropriate screw insertion and remains a technically demanding procedure. TBP fixation is a well-recognized technique for treating the posterior pelvic ring disruption [10, 11]. But pre-bending of LCP for adapting the structure of posterior pelvic ring, which may reduce the strength of the plate or damage the threads of screw holes, affects pelvic stability fixed with LCP [12]. Although triangular osteosynthesis can create the necessary stability for the maintenance of reducing unstable pelvic fractures, it restricts the range of L5/S1 motion segment [13, 14]. To address the above mentioned limitations, we introduced a novel minimally invasive adjustable plate (MIAP) according to the structure characteristics of posterior pelvic ring. This article attempted to review our techniques of MIAP and provide clinical results.

Materials and methods

The study was approved by the Ethics Committee of our hospital.

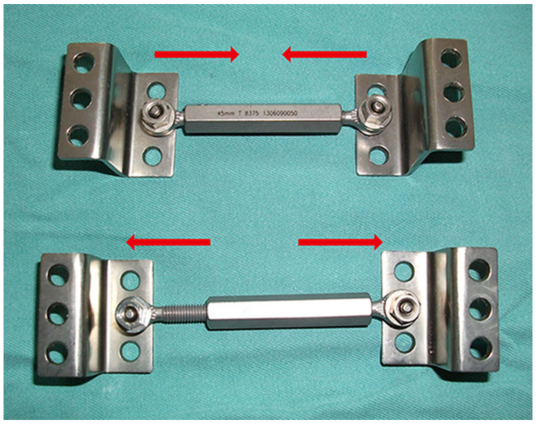

Figure 1. Structure of minimally invasive adjustable plate (MIAP). Both Z-shaped brackets can be compressed or separated by rotating the hexagonal tube.

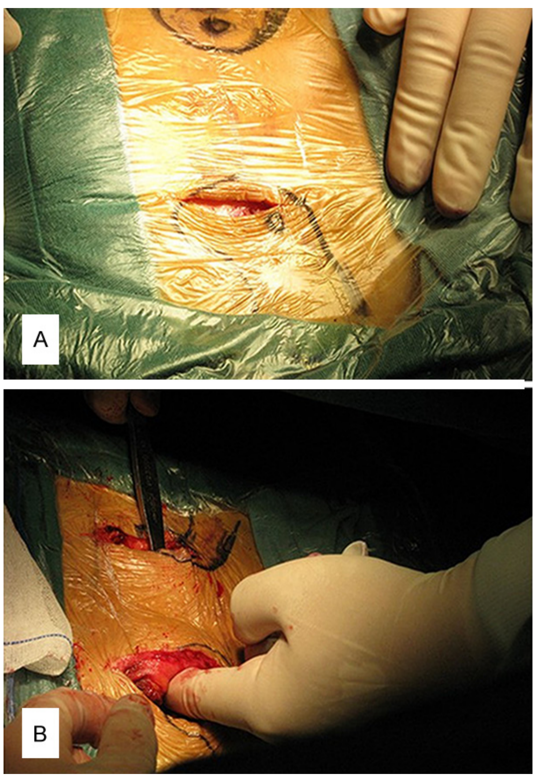

Figure 2. A. Longitudinal incision 4-6 cm long was made along PSIS. B. A subcutaneous tunnel was created between bilateral PSISs.

Subjects

Between January 2009 to July 2012, 26 patients with unstable pelvic ring fractures were included in this investigation. After at least 12-month follow-up, one patient died and 4 patients failed to be followed up. Finally, 21 patients were enrolled in this study. Of these, 10 patients had injury caused by traffic accident, 7 by fall from height, and 4 by crush. The pelvic injuries were AO/OTA 61-Type B in ten cases (4 Type B1, 4 Type B2, 2 Type B3) and Type C in eleven cases (6 Type C1, 3 Type C2, 2 Type C3). The average duration from injury to operation was 7.8 days (range, 2-20 days). Of the 21, twelve were associated with multiple injuries, including head injury in one case, haemopneumothorax in two, L4 lumbar fracture in one, acetabular fracture in two, extremities fractures in seven, urethral disruption in three, laceration of perineum in two, bladder injury in two and renal contusion in one. The mean Injury Severity Score (ISS) [15] was 13.8 (range, 9-29).

All patients received plain X-ray films (anteroposterior, inlet, and outlet views) of the pelvis before operation and an experienced radiologist (Z.Z.K.) was assigned to read these films. Computed tomography (CT) scanning and three-dimensional (3-D) reconstruction were performed to determine the involved fracture portion, the type of fracture, and stability of the pelvis.

Operative technique

The MIAP (Tianjin Zhengtian Medical Instrument Company Ltd., Tianjin, P.R.C.) is composed of two Z-shaped brackets and an adjustable connection bar (**Figure 1**). Each Z-shaped bracket consists of an upper wing, a web plate, and a lower wing. The connection bar is made up of two custom made eye bolts and a hexagonal tube, which can be shortened or stretched by rotating the hexagonal tube. Both Z-shaped brackets connect to the eye of the bolt to integrate these implants as a whole.

Under general anesthesia or continuous extradural anesthesia, the patient lay in a prone position. Bilateral longitudinal incisions 4-6 cm long were made along the posterior superior iliac spines (PSISs) after sterilizing and draping. The bilateral PSISs were exposed after the skin and subcutaneous tissue had been incised to the periosteum without releasing the gluteal muscles from the outer side of iliac crest. The subcutaneous tunnel was created between bilateral PSISs, which were close to the dorsal surface of the sacrum (**Figure 2**). The displacement of fracture or dislocation was assessed

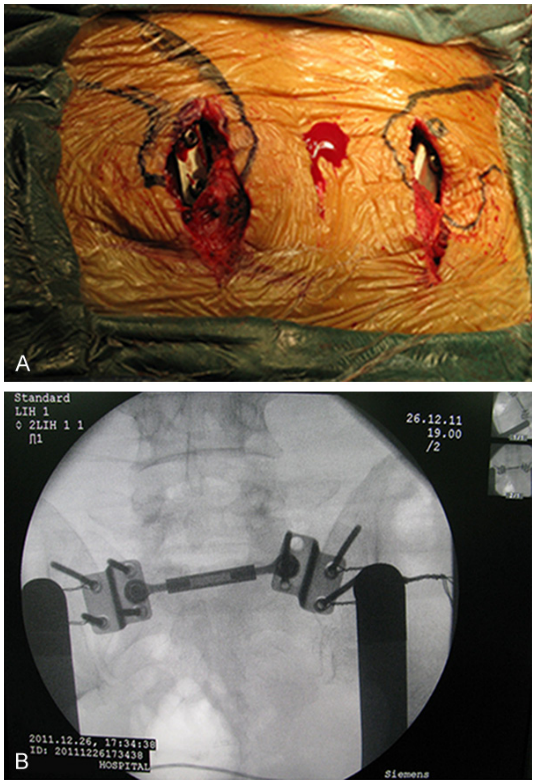

Figure 3. A. Intraoperative view of the placement of MIAP. B. Intraoperative fluoroscopy image demonstrated the position of the MIAP and the reduction of the fractures.

again by using C-arm X-ray machine and reduced as follows. The cephalad displacement of the sacral fracture or sacroiliac joint was reduced by continuous traction. For outward rotational displacement, it was reduced by compressing the affected iliac wing. When it came to ventral or dorsal displacement, a coarse thread screw was implanted into the affected PSIS in order to pull or press the pelvis, and then the screw was pulled out after reduction. Each Z-shaped bracket was positioned with the web plate close to the medial surface of the PSIS and the upper wing lying on the dorsal surface of the PSIS. Two or three long cancellous screws were inserted into the iliac crest through the holes of the upper wings in order to secure the Z-shaped bracket on the ilium. Two screws were inserted into the sacral ala, if possible, to improve the stability of fixation. The connection bar was placed through the subcutaneous tunnel and fastened to the brackets. If the median sacral crest obstructed the bar, we would make 2-3 cm longitudinal incision in the midline of sacrum or oblique incision from one side of PSIS for resecting the median sacral crest. If the sacral fracture still presented separation or compression shift in coronal plane, the hexagonal tube was rotated to shorten or elongate the bar under C-arm X-ray fluoroscope, which in turn reduced the separated fracture or distracted the compressed fractures, respectively (**Figure 3**).

Once fixed, the incision was irrigated and closed appropriately with suction drains. The incision site was covered with a well-padded dressing and the patient was put in a non-weight-bearing position, postoperatively. The suction drains were taken away within 24 h usually. The patient was encouraged to take active exercises 3-4 days after operation. Crutch-assisted walking was allowed after two weeks. Partial weight-bearing began at six weeks postoperatively. Progression to full weight-bearing was determined on the basis of osseous union on pelvic radiographs.

Postoperative functional recovery was assessed with the Majeed score standard [16], which includes five aspects: standing (36 points), pain (30 points), working ability (20 points), sitting (10 points), and sexual life (4 points). The maximum score is 100 points, with excellent ≥85 points; good 70-85 points; fair 55-69 points; and bad ≤55 points.

Results

There were no iatrogenic neurovascular injuries during the operations. The average duration of surgery was 67.5 min (range, 40-90 min), the intraoperative blood loss was 204 ml on average (range, 150-250 ml), the average radiation exposure was 8 s (range, 6-10 s), and the size of incision was 8.8 cm on average (range, 7-12 cm). The fractures healed without internal fixation loosening or breakage. After operation, the mean Majeed functional evaluation score was 85.3 points (range, 75-97 points) (**Figure 4**).

Discussion

Sacral fractures and dislocation of sacroiliac joint are complex injuries, accompanied with vertical and rotational instability. Early reduction and fixation can greatly reduce long-term complications such as abnormal gait, pain and posture. If the reduction and fixation is not prompt, the operative outcomes are unsatis-

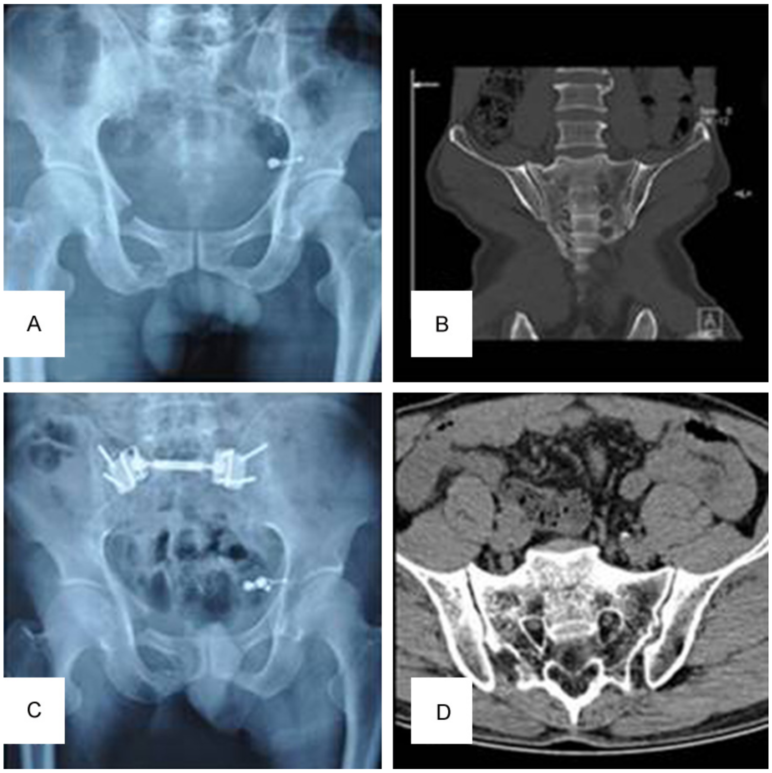

Figure 4. A 57-year-old male sustained pelvic fracture (OTA 61-C1) due to fall from height. The posterior pelvic ring was fixed with MIAP. A. Preoperative pelvic radiograph demonstrated sacral fracture associated with fractures of pubic rami (anteroposterior view). B. Preoperative CT image demonstrated right sacral compressed fracture (coronal view). C. Pelvic radiograph was taken at three months postoperatively (anteroposterior view). D. Pelvic CT was taken at thirty-one months postoperatively.

factory and the postoperative residual symptom and dysfunction are also common [17]. Therefore, early surgical treatment for posterior pelvic ring injury is beneficial [18]. However, there is no consensus on the optimal fixation technique for these injuries [19].

IS screw fixation is one of the most frequently used methods with satisfactory results. However, this fixation is a highly technical procedure that requires extensive surgical experience [20]. In addition, surgeons and patients are exposed to large amounts of radiation during operation [21, 22]. Some studies reported that the average fluoroscopy time for IS screw fixation ranges from 26 s to 5.7 min using a C-arm [23-25]. Improper position, length, and direction of the IS screws can lead to iatrogenic neural, vascular, or visceral injuries.

TBP technique is an optimal treatment of choice for unstable pelvic fractures. Tang treated posterior pelvic ring disruptions with TBP and obtained satisfactory functional outcomes [26]. However, pre-bending of TBP can reduce the strength of the plate or damage the threads of screw holes, which affects the stability of pelvic fractures fixed with TBP [12]. Krappinger *et al.* treated 23 patients with vertically unstable pelvic injury using TBP fixation, and found that the average residual displacement of fracture remained at 6.1 mm [27]. Ayoub et al. reported a skin infection rate of 12.5% when TBP fixation was used for the unstable vertical fractures of the sacrum [28]. Suzuki treated 19 patients with vertical fractures of the sacrum, of which two patients had skin infections [19].

Triangular osteosynthesis is a new option for the treatment of unstable pelvic fractures and can provide improved fixation for maintaining reduction. But it comes at the cost of crossing the L5/S1 motion segment [13]. In a clinical series of 40 patients, it produced significant rates of low-back pain (95%) and subjective restricted range of motion [14].

To address the limitations and avoid potential complications, the MIAP was introduced as an alternative to treat unstable pelvic fractures. The MIAP can be used to fixate the posterior pelvic ring fractures without pre-bending because it conforms to the anatomical structure of posterior pelvic ring. In the current study, 21 patients were treated using MIAP. The separated posterior pelvic fractures were reduced partially by shortening the connection bar, and the compressed sacral fractures were reduced by lengthening the connection bar. Surgeons realigned the displaced bones into a suitable position by gradually rotating the bar under fluoroscopic guidance. There was no iatrogenic neurovascular injury occurred. Excellent or good functional outcomes were observed in this group of patients.

Biomechanical experiments showed the MIAP provided rigid stabilization for posterior pelvic ring injuries. The Denis type I vertically sacral fracture models were fastened to the Electroforce 3520-AT Bose biomechanical testing machine in sitting position and fixed with MIAP and LCP, respectively. Under 600 N vertical load, the average displacement of the pelvis fixed with MIAP was 1.3 mm, significantly less than the average displacement of 1.8 mm fixed with LCP [29].

The fixation of MIAP was a minimally invasive procedure and easy to perform. The average duration of operation is 67.5 min. During operation, two or three small incisions were made to implant this fixation with an average of 204 ml blood loss and the size of incision was 8.8 cm on average. This procedure could avoid iatrogenic injury to the superior gluteal nerve, veins and arteries, as the muscles attached to the posterior iliac wing were not stripped off. The incision healed well and no wound complication or deep infection occurred. Irritative symptoms or pressure sores were not complained since the bar lay closely to the dorsal of the sacrum. However, some patients treated with TBPs may feel uncomfortable due to the subcutaneous implant [26]. In this study, the screws were inserted into the sacral ala through these holes in the lower wing of the MIAP in six patients, which can provide sufficient stabilization. Molina et al. found that drilling and screwing into the sacral ala was a safe surgical procedure [30]. There was no iatrogenic neurovascular or visceral complication happened.

To assess the reduction quality intraoperatively, the shots of fluoroscopy (anteroposterior, inlet and outlet views) were taken and continuous shots were not taken. In addition, direct visualization of this operation is helpful to reduce the need of intraoperative radiation. Therefore, the average radiation exposure was 8 s, which was less than the radiation exposure in placement of IS screws [23-25].

The MIAP has the advantages of technically safe, minimally invasive, less radiation exposure and time saving. It can be used to reduce the separated or compressed sacral fractures and sacroiliac joint dislocations. The use of MIAP can achieve favorable clinical and radiological outcomes, which is a good supplementary option for treating unstable pelvic fractures.

Disclosure of conflict of interest

None.

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