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Modified screw-rod fixation for management of posterior pelvic ring fractures: a retrospective study

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Abstract

Background Pelvic fractures are often associated with life-threatening damage and mechanical instability. Surgical therapy is a prior choice. To minimize surgical invasion and risk, bilateral screws combined with curved rod were applied to stabilize posterior pelvic ring. This study was aim to explore the clinical effect of this procedure.

Methods From January 2018 to January 2022, 27 patients with posterior pelvic fracture were included retrospectively. There were 12 males and 15 females with an average age of 56.3 ± 14.2 years. The prognosis of pelvis was evaluated by Matta and Majeed scores. Relevant clinical evaluation indications include the time of fracture healing, limb function and complications.

Results The average follow-up time was 14.2 ± 5.4 month. Matta scoring standard: excellent in 18 cases, good in 7 cases, the good rate was 92.6%. The average healing time was 8.4 months. The standard of Majeed score in 6 months after operation: excellent in 14 cases, good in 10 cases, the good rate was 88.8%. At the last follow-up, the functional recovery of the affected limb was satisfactory. No deep infection occurred after operation. The neurological symptoms of patients with caudal sacral nerve injury were recovered 6 months after operation.

Conclusion The results indicated that screw-rod system is a safe technique. Minimally invasive technology reduced frequency of fluoroscopy. It provides a simple and safety method for posterior pelvic fracture.

Keywords Pelvic fracture, Screw-rod system, Unstable pelvic ring

Background

Unstable pelvic ring fractures are severe injuries, related with high-energy trauma [1]. Main causes are traffic accidents or falls from different heights [2]. High mortality and complication rates are associated with hemodynamic instability and mechanical malfunction of pelvic ring [3]. The predominant unstable fracture morphology involves posterior pelvic ring. Various treatments with reduction and fixation are aimed to reconstruct pelvic stabilization and enhance recovery. However, pelvic fracture especially posterior ring is difficult to restore because of complex anatomical structure and biomechanics. Long-term complications like postoperative pain, restricted activities, fixation loosen, bone nonunion and malunion are still a challenge for surgeons.

Open reduction and internal fixation remain a favorable choice to provide proper anatomical reduction and biomechanically stablility. The prevalence of using minimal invasive technique with less operation time, as well

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as blood loss, is still low [4]. To enhance the stability of posterior pelvic ring, some studies reported the placement of iliosacral screws [5]. The screw method bridging the bilateral iliac region is minimally invasive, reduces surgery trauma, provides pain relief and primary stability [6]. However, iliosarcral screws system was faced with two challenges: (i) how to reduce a fracture or dislocation before fixation, (ii) this technique with accurate position would pose risks of frequent radiation exposure to both patients and surgeons.

In biomechanical study, transiliac internal fixation has sufficient stability [7]. Dual iliac fixation reduced the possibility of postoperative rotation, displacement of bone fragments and hardware displacement [8]. The fractures were reduced through posterior incision. To ensure accurate screw placement and reduce risks of neurovascular injury, preoperative 3D model was applied. Trans iliac screw-rod fixation was used in trauma patients. If vertical displacement was happened, we linked iliosacral screws with lumbar pedicle screw. The purpose of this study was to evaluate the clinical effects of this modified screw-rod fixation for treating unstable pelvic injuries.

Methods

The present study retrospected the data from January 2018 to January 2020. A total of 27 patients with unstable pelvic ring fracture underwent both minimal invasive pedicle screw-rod fixation and anterior external fixation in our institution. The inclusion criteria were an age of >18 years old, hemodynamic stability that support patients tolerating surgery well, clear consciousness, unstable pelvic ring injury requiring posterior fixation and completely collected follow-up data. Patients with soft tissue defects, open fractures and serious osteoporosis were excluded. This research has been approved by the Institutional Review Board of Mianyang Central Hospital.

Every case was supervised by ECG monitoring. Vessel ultrasound was routinely performed to screen for vascular injury or venous thrombosis. For patients over 60 years old, echocardiography was used to evaluate heart function. Anteroposterior, inlet and outlet pelvic radiographs were taken in all patients. Computed-tomography (CT) scan was further evaluated displaced fracture. The CT images were loaded to rebuilt 3D model by Mimics software [Fig. 1]. In preoperative model, we confirmed the safe bone corridor. The osseous entry point was 1 cm below the posterior superior iliac spine. The bone channel was established toward the greater trochanter of femur.

Surgical procedures

The prone position was employed. The posterior superior iliac spine (PSIS) was marked. Bilateral 6 cm incisions were used 0.5 cm medially along the PSIS. Cortical bone was removed before guide needle insertion. The purpose was to prevent screw cap from soft tissue compression. We probed the inner and outer plates of the pelvis and

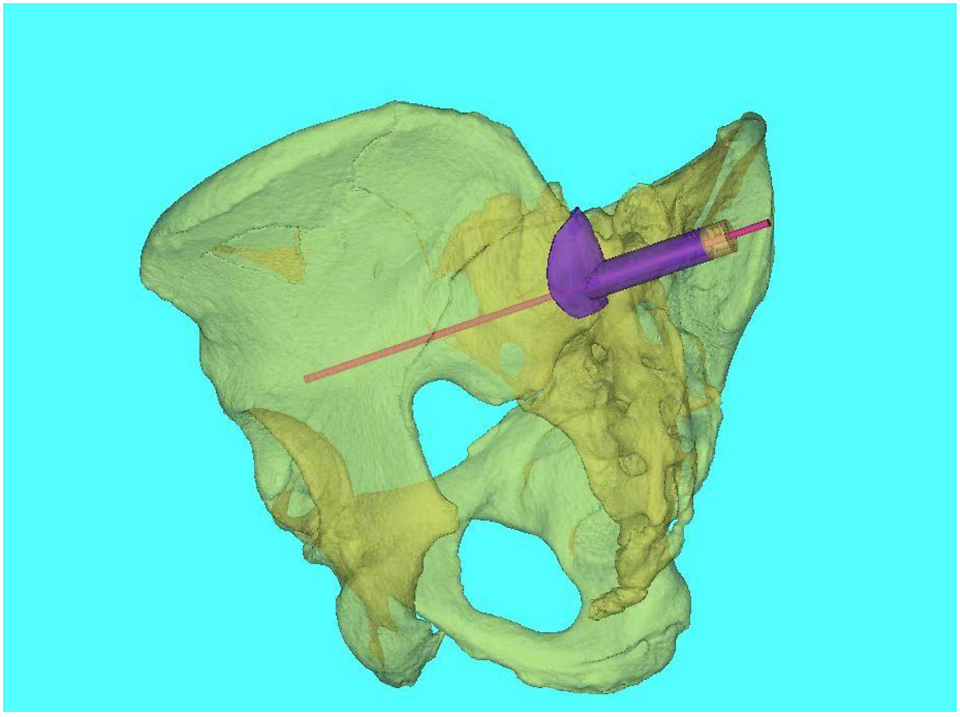

Fig. 1 The 3D visualization of bone corridor (red line)

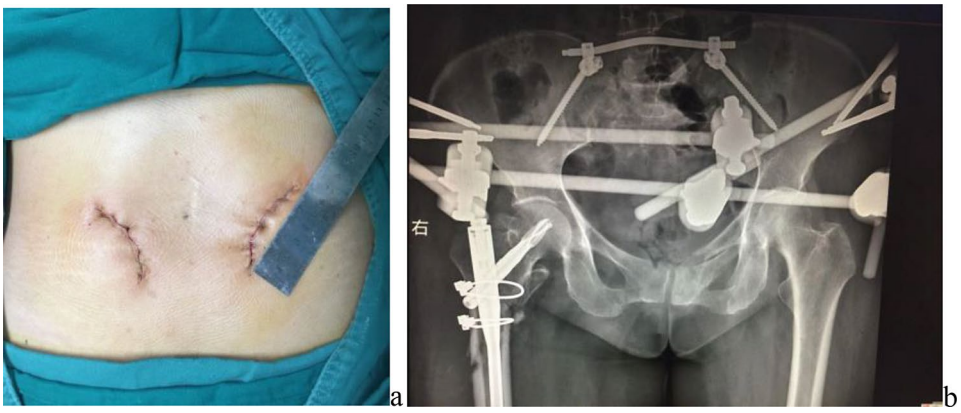

Fig. 2 Posterior surgical incisions for screw-rod fixation (**a**). Postoperative plain X-ray showed anteroposterior appearance (**b**)

Fig. 3 The lumbar screws were added to restore vertical stability

explore the shape of ilium. The direction of inserted guide device was in accordance with preoperative model. The corridor above the greater sciatic notch was checked that we did not penetrate the iliac wing. Iliosacral screws were fixed to the bilateral dorsal iliac wing through guide device. The iliosacral screw was a 6.5 mm screw with a length of 65 mm. A titanium rod with 6 mm diameter was applied to connect the two screws. After adjusting the rod to the right place, the caps of screws were tightened. The screw positions and reduction was examined by fluoroscopy inlet and outlet views. A typical patient was showed in Fig. 2.

In case of vertical unstable fracture, patients were added lumbar fixation. The iliac screw was linked with lumbar pedicle screw (Fig. 3). If anterior pelvic ring was unstable, patient was managed by anterior pelvic external fixation. A 1 cm incision was made below the anterior superior spine. Soft tissue was dissected to expose iliac crest. Two pins were inserted on each side of the pelvis. Before connected to the external fixation, pins channels were confirmed with fluoroscopy.

The postoperative rehabilitation

All patients were managed to start functional exercises of lower limbs without bearing from postoperative day 1. After acute pain period, patients were encouraged to take active and positive joint exercises. After 3 weeks, sitting was permitted by the patients. The anterior pelvic external fixation was removed 4 weeks after operations. The crutch-assisted walking was performed by the patients at 6 weeks postoperatively. Patients were allowed to gradually walking with full weight bearing when postoperative imaging demonstrated bone union. Follow-up were ordered at 4 weeks, 8 weeks, 12 weeks, 16 weeks, 24 weeks, 9 months, 12 months, 15 months, 18 months postoperatively.

The radiological findings of pelvic ring were assessed by Matta criteria which measure maximal displacement

by anteroposterior, inlet and outlet radiographs: excellent (<4 mm), good (5–10 mm), fair (11–20 mm), poor (>20 mm) [9]. The quality of clinical function was evaluated by Majeed criteria which include pain, sitting, standing, sexual intercourse and work. The overall score was 100. The full score was 80 while no score was obtained for work because of patients without work before operation [10].

Results

There were twelve males and fifteen females, averaging 56.3±14.2 years old (range, 25–74). According to Tile classification, 19 patients were diagnosed with type B (B1 in 10 cases, B2 in 7 cases, B3 in 2 cases) and 8 cases were type C. Based on Young-Burgess classification, there were 7 patients with anterior posterior compression (APC-II in 5 cases, APC-III in 2 cases), 12 patients with lateral compression (LC-I in 2 cases, LC-II in 7 cases, LC-III in 3 cases) and 8 patients with vertical shear. The results showed cerebral concussion in 3 cases, scalp laceration in 2, pulmonary contusion in 2, pneumothorax in 5, urethral injury in 5. The mean time to surgery was 3.6±2.3 days after admission. In this study, 8 cases were added lumbar pedicle screw. 20 cases were added anterior pelvic external fixation. The operation took an average of 2.6±0.8 h (2.3±0.7 h in type B, 3.3±0.6 h in type C). The mean blood loss volume was 200.0±66.7 ml in type B and 264.3±85.2 ml in type C respectively. The number of fluoroscopy exposures was 3±2 times. The mean voltage and the mean electric current of C-arm fluoscopy were 75 kV and 6.0 mA, respectively. The time of radiation exposure was 1 min. The severity of pain before surgery was 7.5±1.2 according to the VAS. A week after surgery, the pain was relieved to 2.8±0.7.

In this study, no case was developed incision infection. Superficial exudation is more in 1 patient. No bacteria were found in secretion culture. The wound was delayed one month after operation. 1 patient experienced sensory disturbance of affected limb.

All patients were available for followed up. The mean time was 14.2±5.4 months. During the follow-up period, no delayed osseous union or nonunion was found from examination. The average time of bone healing was 8.4±6.7 months. Matta evaluation results were excellent in 18, good in 7, and fair in 1. Majeed evaluation scores were performed 6 months and 12 months postoperatively. The results showed excellent in 13, good in 10, fair in 3 at 6 months. It was excellent in 14, good in 10, fair in 2 at 12 months after operation.

Discussion

The treatment of pelvic fracture includes operation and conservative treatment [11]. Apart from causing pain and related immobilization, the dislocation of bone fracture affects the quality of life. The posterior pelvic ring, especially sacroiliac joint, afford axial loading and transmit trunk weight to the lower limbs [12]. When the displacement is <1 cm, the posterior skeleton-ligament complex is generally considered intact [13]. In our opinion, the degree of fracture displacement might be more severe at the time of injury. A displacement was reduced because of muscle traction. Therefore, the displacement degree presenting on the images could not reveal the real degree of pelvic injury. It is necessary to conduct pelvic compression and separation test. MRI is accessible to detect sacroiliac articulation damage.

Iliac screws as pelvic fracture control surgery was introduced in 1973, followed by a screw-rod system [14, 15]. Considering its advantages, like minimally invasive, effective fixation, this technique has become popular methods. Song Y et al. used pedicle screw rod system for the treatment of Tile C pelvic fractures which can obtain sufficient biomechanical stability [16]. The overall maximum stress of the pedicle screw rod fixation occurred near the greater sciatic notch on the injured side (12.7 MPa to 14.6 MPa). The results revealed a satisfactory quality of fixation.

With the development of assisted techniques, intraoperative CT, 3D navigation was combined with iliosacral screw insertion [17, 18]. 3D reconstruction software are very effective tools for preoperative planning [19]. To acquire better reduction and accurate position of screws, radiation exposure is inevitable. Inserting screws under the guidance of C-arm fluoroscopy is a reliable technique [20]. Both 2D and 3D fluoroscopy would provide good visualization for placing screws during operation [21]. Howerver, the number of fluoroscopy exposure/ the time of exposure in minimally invasive screw fixation group was much higher than in the open reduction group [22].

On the one hand, we selected screw-rod system to meet suitable biodynamic outcomes. Recent literature demonstrated that the regions with higher bone density are iliac cortex and sacro-iliac joint [23]. when the fixation linked bilateral ilium, it could resistant to rotation and vertical shear stress. The junction of the pedicle screw and the ilium was the maximum stress point. In Dienstknecht study, there were no significant differences in displacement at the sacroiliac joint. The screw-rod fixation provided the same stability as iliosacral screws and plate [24]. On the other hand, the inserting method was modified to reduces the risk of neurovascular injury as well as radiation exposure. The choice of posterior incision was along the inner side of iliac spine. The direction of screw placement was on the basis of iliac shape and preoperative 3D model. The mean number of fluoscopy exposures was 3 times. The time of radiation exposure was decreased. Partial bone resection of the PSIS at the entry point for settling the screw heads was preferred to

reduce the degree of soft tissue irritation. During the follow-up, it was found that no patient suffered from postoperative discomfort.

Baumann F et al. reported that reconstruction of the pelvic anatomy and the load bearing depend on treatment of the anterior pelvic ring [25]. The anterior pelvic ring structure and the posterior ring structure account for 40 and 60% of the stability of the entire pelvic ring, respectively. The loss of anterior pelvic ring increases in shear force and vertical tension on the sacroiliac joint [26]. The importance of the anterior pelvic ring should not be ignored. We added anterior pelvic external fixation to enhance fixation strength in patients with anterior pelvic ring fracture.

Due to the various differences of pelvic structure, posterior incision can help surgeon reduce fracture displacement and judge the direction of iliac screw placement. The risks of peripheral blood vessels, nerves or organs damage were declined. Our modified methods maked the operation with lessl radiation exposure. The average follow-up period was 14.2±5.4 months. The excellent and good rate of Majeed was 88.2%. The incidence of bone nonunion and limb function limitation was low.

Limitations need to be acknowledged. This was a single-center retrospective study. More cases should be taken into account. If biomechanical analysis was added, the results would be more convinced.

Conclusions

Screw-rod fixation is effective for treating posterior pelvic ring fracture. Compared with traditional open reduction and internal fixation, the screw-rod fixaiton has some advantages including less trauma, lower fluoroscopy exposures, fewer complications, as well as precise positioning. This modified fixation could be an appropriate method for unstable pelvic fractures.

Author contributions

Junqi Huang and Jiajia Cheng contributed equally to this work. Junqi Huang and Jiajia Cheng conceived the study. Junqi Huang, Tao Wang, Heng Yang and Bo Shi performed the surgery. Shitian Tang, Nan Ye and Dingwei Zhang collected and analyzed the data. Jiajia Cheng drafted the manuscript. All authors read and approved the final manuscript.

Data availability

The datasets used and/or analysed during the current study are available from the corresponding author.

Declarations

Ethics approval and consent to participate

Informed consent was obtained from all subjects and/or their legal guardian(s). We promised that data was applied for effective analysis alone, keeping individual information confidential. Study procedures and materials were approved by Mianyang Central Hospital Ethics Committee (S20240357-01).

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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