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Interval *versus* external fixation for the treatment of pelvic fractures: a comparative study

Abstract

Purpose: This retrospective study evaluated the efficacy and safety of internal fixation (IF) in the treatment of pelvic fractures (PF).

Methods: A total of 263 unstable PF patients were treated from February 2009 to April 2015. Patients were divided into two groups according to type of fixation used to treat their PF: 136 cases received IF surgery (IF group); and, 127 cases received external fixation (EF) surgery (EF group). Postoperative follow-ups were conducted to record the clinical data, perioperative clinical indicators, Matta scores for fracture displacements, Majeed scores for hip functions and postoperative complications.

Results: Operation time, blood loss, the total length of the wound, postoperative fever rate, hospitalization time and complication rate for the IF group were significantly decreased in comparison with the EF group, while the ratings of pain, working and sitting ability and Matta and Majeed scores of the IF group were significantly higher than those of the EF group.

Conclusion: IF was found to be associated with shorter operation times, less blood loss and better postoperative rehabilitation in comparison with EF, suggesting that it is an effective therapy for the treatment of unstable PF and will lead to restoration of normal pelvis functions.

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Pelvic fracture (PF) is a serious injury, accounting for 2 to 8% of all types of fractures. PF's rate of complications and mortality is high, which has serious impacts on human health [1]. The most common complications involve genitourinary system-related injuries, which are correlated with greatly increased rates of cesarean section in women and prostatic urethra or bladder neck injury in men, and the injury may cause a high mortality rate as it cannot heal automatically [2-4].

PF can be classified into two types: stable and unstable. Although stable PF can be treated non-operatively, unstable PF is more severe and requires more complicated surgical procedures [5]. Immediate external fixation (EF) is a technique, which was originally described in 1985, that can be used to stabilize severe pelvic fractures and reduce the chance of organ failure and death [6]. It effectively reduces bleeding from PF by supplying tamponade, reduces the volume of the pelvis and brings the fracture fragments into apposition [7]. Due to the complexity of PF injuries, EF can prevent worsening of the damage, but it does not always achieve clinically satisfactory results [8].

EF was found to be useful only in the acute phase of resuscitation and was limited in the definitive treatment of an unstable pelvic injury due to its inability to control vertical translation and posterior diastasis [9]. A study suggested that internal fixation (IF) was feasible and effective in the treatment of PF due to its minimal trauma advantages, less bleeding, rapid healing and satisfactory reduction [10]. Currently, IF is being promoted as a surgical procedure for treatment of severe PF and has been proven to effectively restore stability around the pelvic ring. Together with EF, IF has become a standard treatment for unstable PF [11].

By comparing the outcomes of IF and EF, this retrospective study highlights the safety and efficacy of IF surgical treatment for PF.

Materials and Methods

Study subjects

From February 2009 to April 2015, a total of 263 PF patients admitted to our hospital (male/female 166/97, mean age 37.95 ± 12.85 years; 14-69 years) with unstable pelvic ring fractures (types B and C) who had undergone surgery within the 2 weeks after injury and had complete clinical data were recruited to this study. PF patients with unstable pelvic ring fractures (type A), who received only conservative treatment, or for whom incomplete clinical data were available were excluded from the study. According to Tile's classification

[12], the fracture types were classified as follows: type B, 118 cases (B1 60, B2 36, B3 22); and, type C 145 cases (C1 89, C2 36, C3 20) (Figure 1).

This study was performed in accordance with the guidelines established by our hospital, and all patients gave signed informed consent.

Surgical approaches

After a precise preoperative examination and careful early treatment for life threatening complications (e.g., massive hemorrhage and shock), patients were divided into two different groups according to the fixation characteristics of PF: 136 cases received IF surgery (IF group); and, 127 cases received EF surgery (EF group). For simple PF injuries, the surgeries were performed 5-7 days after the injury. For patients with other organ damage, the surgeries were delayed till the patients were stable.

Open reduction and internal fixation (ORIF) procedures included 16 cases of pubic symphysis separation, 54 cases of pubic ramus plate at the upper limb and 66 cases of anterior double-plate fixation in the IF group. For the pubic symphysis separation of ORIF, the patients lay in a supine position with their lower limbs disinfected. A lateral and arcuate incision was made at 2 cm above the superior pubic ramus. The external oblique aponeurosis was cut until the rectus abdominis was cut off to expose the anterior, posterior and the top surface of the pubic bone. Care was taken to avoid damaging nearby tissues and organs including the spermatic cord, where applicable. After the pubic symphysis, a 4 to 6-hole metal plate was placed at the top edge of the pubic bone for fixation. After the operation, the retropubic cavity was suctioned to drain the fluid inside. In the superior pubic branch incision of ORIF, the incision was made by pubic symphysis separation, and the distal half of the external oblique aponeurosis was flipped down to strip off the blood vessels and muscle nerve sheaths. The outer edge of the incision under the periosteum was also stripped off, exposing the inner plate of ilium and the upper branch of the pubis. After the repair of the fractures, the steel reconstruction plates were inserted under the vascular sheath and muscle nerve sheath along the top edge of the pubic bone and were fixed in place with screws. During the anterior open reduction and double-plates internal fixation procedures, the anterior path of insertion and fixation was through an ilioinguinal incision: an incision was made parallel to the rear side of the iliac crest, and the iliac plate, sacroiliac joints and sacroiliac wings were removed. The sacroiliac joints were then restored. At both sides of sacrum and ilium, one and two screws were installed, respectively. Double plates were then

CONSORT

TRANSPARENT REPORTING of TRIALS

CONSORT 2010 Flow Diagram

FIGURE 1. Flow chart of patient selection.

installed to fix the sacroiliac joints. In general, drainage tubes were put in place after the surgery and removed after 24 h (Figure 2).

In the EF group, patients underwent external fixation or percutaneous fixation operations. During the EF operation, the patients lay in a supine position. A small incision was made at 2 cm behind the anterior superior iliac spine connection. Using vessel forceps, soft tissues were separated and the ilium was exposed. The iliac crest cortical tissue was drilled through and screws were installed inwardly along the plate barrier. A similar procedure was done on the anterior superior iliac spine.

Aided by C-arm X-ray imaging, the external fixation screws were locked (Figure 3).

Postoperative treatment

In addition to general routine physical and psychological post-surgical care for the patients in both groups, precautions were taken to prevent shock, infection, pressure sores and abdominal distension, to control pain and to prevent physical activity. Analgesics were given and their effectiveness was monitored.

Both groups of patients underwent rehabilitation training: at 1 week after the surgery, flexion and extension exercises were

FIGURE 2. X-ray of a 47-year-old male PF patient before and after open reduction IF treatment: (A) before treatment; and, (B) after treatment. IF, internal fixation; PF, pelvic fractures

FIGURE 3. X-ray of a 51-year-old male PF patient before and after EF treatment: (A) before treatment; and, (B) after treatment. EF, external fixation; PF, pelvic fractures.

implemented from toe to ankle at a gradual pace; at 2 weeks after the surgery, flexion and extension training on hip and knee joints was started; at 3 weeks after the surgery, training to strengthen joint activity was started; at 6 to 8 weeks after the surgery, patients started to walk with crutches and gradually started full weight-bearing; and, at 12 weeks after the surgery, patients gradually learned to walk with crutches until full recovery. At all stages during recovery, patients were under constant observation.

Treatments were supplemented with traditional Chinese medicine: at the early stages, Tao Hong Si Wu decoction was administered and Xiao Yu analgesic ointment applied locally; at the medium-term stages, Jie Gu Qi Li tablets were administered; and, at the later stages, attention was paid to optimizing nutritional intake.

Postoperative observation and evaluation

Patients in the two groups underwent postoperative evaluation. At 6 months post-surgery, X-ray images of anterior, posterior, entrance and exit positions of the pelvis were taken to evaluate the progress of fracture healing. The fracture restoration efficacy was evaluated according to Matta fracture displacement scoring [13]: pelvic ring displacement < 4 mm is excellent; 4 to 10 mm is good; 10 to 20 mm is adequate; and, > 20 mm is poor. The Majeed hip functioning score [14] was used to evaluate postoperative pain, physical ability, gait, recovery of working capability and the restoration of nerve injury: a score of 85 to 100 is considered excellent; 70 to 84 is good; 55 to 69 is adequate; < 55 is poor.

Postoperative follow-up

Through telephone or in-patient visitation, all patients in both groups underwent follow-up evaluations conducted by the same physician for six months post-surgery. The follow-up rate was 100%. Postoperative recovery and rehabilitation efficacy were recorded and then evaluated independently.

Statistical analysis

SPSS20.0 software was used to process all data for statistical analysis. The measurement data are presented as mean $\pm$ standard deviations. The comparison between two groups was done using the *t*-test. All count data are presented as percentage or rate values, and were verified using the χ^2 test. A *P* value < 0.05 was considered statistically significant.

TABLE 1. Baseline characteristics of patients in the EF and IF groups

Characteristic	EF group (n=127)	IF group (n = 136)	<i>t</i> / χ^2	<i>P</i>
Age (years)	38.65 $\pm$ 12.85	37.30 $\pm$ 12.86	0.851	0.396
Gender			0.046	
Male	81	85		
Female	46	51		
Body size			0.604	0.739
Below normal	17	14		
Normal	83	92		
Above normal	27	30		
Location of injury			1.054	0.305
Left side	65	61		
Right side	62	75		
Cause of injury			3.292	0.193
Car accident	96	89		
Fall	19	30		
Heavy object accident	12	17		
Type of fracture			0.251	0.616
Tile B type	59	59		
Tile C type	68	77		
Young-Burgess classification			6.046	0.196
LC2	24	31		
LC3	25	19		
APC2	26	17		
APC3	19	29		
VS	33	40		
Time of surgery			0.829	0.363
2 weeks within injury	78	76		
2 weeks after injury	49	60		

IF group = internal fixation; EF group = external fixation; BMI = body mass index (kg/m²); thin = BMI < 24; normal = 18.5 $\leq$ BMI < 24; fat = BMI > 24; LC = lateral compression; APC = anterior-posterior compression; VS = vertical shear.

Results

Comparison of clinical data

The general clinical data from the two groups were compared in Table 1. There were no differences in age, sex, body size, location of injury, cause of injury, fracture type, Young-Burgess classification and surgical timing between the two groups (all $P > 0.05$).

Comparison of perioperative clinical parameters

In the perioperative clinical parameters for the two groups (Table 2), the mean operative time for IF patients was 74.97 ± 1.93 min (70.20 to 90.70 min), the average blood loss was 53.91 ± 14.44 ml (23.83 to 102.11 ml), the average length of wound was 34.52 ± 4.90 mm (18.80 to 50.50 mm), the average length of hospital stay was 12.44 ± 2.29 d (5 to 20 d), the average length of postoperative fever was 2.63 ± 0.83 d (1 to 5 d) and the postoperative recovery was good. The values of these parameters in IF group were significantly better than those in the EF group (all $P < 0.05$).

Comparisons of post-operative Matta scores of postoperative fracture displacement

At 6 months after the surgery, X-rays were taken for all patients. The Matta scores of fracture displacement are shown in Table 3, and the scores for the IF group were significantly higher than those for the EF group ($P < 0.05$).

Comparisons of Majeed scores of postoperative hip function

At 6 months after the surgery, the two groups of patients underwent Majeed evaluations of hip function and the results are shown in Table 4: compared with the EF group, the ratings on pain, working and sitting ability improved significantly for the IF group (all $P < 0.05$), but the ratings on sex life and

standing ability showed no significant differences (all $P > 0.05$). Overall, the excellence rate of the Majeed scores for the IF group were significantly higher than those for the EF group ($P < 0.05$).

Comparison of postoperative complications

Complication rates for the two groups at 6 months after the surgery (Table 5) were compared and the rates of infection, fracture displacements and overall complications for the IF group were found to be significantly lower than for the EF group (all $P < 0.05$). In the IF group, there were only four people with symptoms of infection, and the infection was well-controlled by washing, debridement and topical antibiotic treatment. In all patients, there were no other complications (such as screw displacements and nerve injury).

Discussion

PF is a complex injury that is generally associated with high-energy damage, which can seriously impact health [1]. It has been shown that, after a fall from a great height, 85% of the patients who sustained a PF bled from the fracture itself, compared with only 44% of the patients who did not sustain a PF after the fall [15]. Despite multidisciplinary approaches in the treatment of PF, mortality remains as high as 40%, with one third of patients dying from an uncontrolled hemorrhage [16]. IF is associated with lower odds of adverse events and nonroutine discharges to inpatient facilities [17]. In this study, the effectiveness of IF and its role in postoperative rehabilitation of PF were compared to EF surgeries, to identify an optimal surgical approach.

This study found that the clinical indicators for the IF group were significantly better than those for the EF group. PF with hemorrhage is an important cause of increased mortality and must be addressed [15]. EF therapy has been used widely

TABLE 2. Comparison of perioperative parameters between the EF and IF groups ($\bar{x} \pm s$)

Parameter	EF group (n=127)	IF group (n=136)	<i>t</i>	<i>P</i>
Operative time (min)	92.74 ± 1.42	74.97 ± 1.93	84.560	< 0.001
Loss of blood (ml)	161.53 ± 15.15	53.91 ± 14.44	58.890	< 0.001
Length of wound (mm)	72.61 ± 5.26	34.52 ± 4.90	60.800	< 0.001
Postoperative fever (d)	4.15 ± 1.37	2.63 ± 0.83	10.960	< 0.001
Hospital stay (d)	16.19 ± 4.69	12.44 ± 2.29	8.323	< 0.001

IF group = internal fixation; EF group = external fixation.

TABLE 3. Matta scores of fracture displacement of patients in the EF and IF groups

Grading	EF group (n=127)	IF group (n=136)	χ^2	<i>P</i>
Excellent	49 (38.58)	71 (52.21)	4.913	0.027
Good	28 (22.05)	39 (28.68)	1.520	0.218
Adequate	34 (26.77)	21 (15.44)	5.098	0.024
Poor	16 (12.60)	5 (3.68)	7.115	0.008
Excellent rate	77 (60.63)	110 (78.89)	13.11	0.000

IF group = internal fixation; EF group = external fixation.

TABLE 4. Majeed scores of postoperative hip functions of patients in the EF and IF groups

Evaluation index	EF group (n=127)	IF group (n=136)	<i>t</i>	<i>P</i>
Score				
Pain	20.41 ± 6.14	23.15 ± 7.12	3.332	0.001
Working	11.49 ± 3.97	13.42 ± 4.49	3.683	< 0.001
Sitting	6.66 ± 1.83	7.46 ± 1.95	3.425	0.001
Sex life	2.46 ± 0.81	2.60 ± 0.86	1.357	0.176
Standing	31.45 ± 7.36	32.65 ± 9.54	1.136	0.257
Grading (n, %)			χ^2	<i>P</i> value
Excellent	48 (37.80)	77 (56.62)	9.329	0.002
Good	31 (24.41)	36 (26.47)	0.147	0.701
Adequate	35 (27.56)	18 (13.24)	8.374	0.004
Poor	13 (10.24)	5 (3.68)	4.432	0.035
Excellent rate	79 (62.21)	113 (83.09)	14.530	< 0.001

IF group = internal fixation; EF group = external fixation.

TABLE 5. Comparison of postoperative complications in patients in the EF and IF groups

Complications	EF group (n=127)	IF group (n=136)	χ^2	<i>P</i>
Infection	15 (11.81)	4 (2.94)	7.709	0.005
Femoral head necrosis	1 (0.79)	0 (0.00)	1.075	0.300
No healing	2 (1.57)	2 (1.47)	0.005	0.945
Displaced fracture	12 (9.45)	1 (0.74)	10.610	0.001
Total number of complications	30 (23.62)	7 (5.15)	18.540	< 0.001

IF group = internal fixation; EF group = external fixation.

due to its ability to reduce venous bone bleeding, but a recent study found that EF cannot easily avoid the risk of displacement in instable vertical fractures [18]. IF is primarily done using a minimally-invasive approach and IF's recent widespread use in the treatment of PF reflects its ability to reduce surgically-related morbidity [19]. IF has, therefore, become widely recognized as the surgical approach that can achieve early anatomic reduction in most unstable PF cases, and a wave of new technologies and materials associated with IF have emerged [20]. In addition, the use of IF in unstable PF has been shown to achieve good internal stability and optimal clinical efficacy [18].

During the follow-up section of this study, the postoperative Matta scores for fracture displacement and Majeed scores for hip functions in the IF group were found to be significantly higher than those in the EF group. Matta and Majeed scores are commonly used criteria for evaluating postoperative pelvic stability, and high Matta and Majeed excellent rates are representatives of near or full anatomic restoration in PF [21, 22]. Research has shown that Matta and Majeed scores and their excellent rates were higher during IF treatment of PF [23]. It has also been shown that the postoperative pelvic ring stability is closely related to the strength of fixation force during IF, and better anterior and posterior pelvic stabilization were obtained with a dual-implant fixation method, which is advantageous in treating PF [24]. In addition, the overall complication rate of IF group was significantly lower than that in the EF group during this study, especially in terms of postoperative infection. Although infection cannot be completely avoided during IF, it is a minimally-invasive surgical method and the probability of infection during IF is lower than that for EF [25].

In summary, with IF the operative time and blood loss were lower and the prognosis was better than with EF and percutaneous fixation surgery, suggesting that IF may be an effective surgical method to restore normal function in patients with unstable PF patients. There are some limitations to this study; for example, a small proportion of patients showed postoperative infection after IF and further research is need to determine how to further reduce infection following IF surgery. In addition, there was a significant difference in the efficacy of IF between PF patients with different types of fractures, which makes universal conclusions difficult. Nevertheless, our study has contributed information of clinical significance for the treatment of unstable PF patients and additional research, particularly systemically investigations, will confirm and strengthen these results.

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