

## Original Article

# Modified minimally invasive percutaneous bridge fixation technique for the treatment of unstable anterior pelvic ring fractures in males

Li-Feng Hu<sup>1\*</sup>, Sheng-Li Dong<sup>1\*</sup>, Kai Yu<sup>1</sup>, Dian-Ying Zhang<sup>1,2</sup>

<sup>1</sup>Department of Orthopedics, The Fifth Central Hospital of Tianjin, Tianjin, China; <sup>2</sup>Department of Orthopedics and Trauma, Peking University People's Hospital, Beijing, China. \*Equal contributors.

Received November 17, 2018; Accepted April 10, 2019; Epub June 15, 2019; Published June 30, 2019

**Abstract:** Objective: The objective of this study was to introduce an improved minimally invasive percutaneous bridge fixation technique. After revealing the spermatic cord, the plate was inserted with the spermatic cord placed above the plate to avoid damaging the spermatic cord. Methods: The medical records and follow-up results of 10 male patients with unstable anterior pelvic ring fractures who underwent modified minimally invasive percutaneous bridging fixation technique from January 2015 to January 2018 were retrospectively analyzed. The evaluating indexes including operation time, blood loss, quality of reduction (Matta criteria) and complications were recorded. The evaluation indexes, including the operative time, blood loss, quality of reduction (Matta criteria) and complications, were recorded. Results: The average operative time was 68.5 minutes (range, 50-120), and the average volume of intraoperative blood loss was 78.0 ml (range, 40-200). The quality of reduction was evaluated using the Matta criteria, as follows: excellent in 7 cases, good in 2 cases, fair in 0 cases, and poor in 1 case. The rate of excellent and good reduction was 90%. No instances of iatrogenic spermatic cord injury or inguinal hernia occurred. Conclusion: The modified minimally invasive percutaneous bridge fixation technique avoids iatrogenic spermatic cord injury and offers a safe alternative method for the treatment of anterior pelvic ring fractures in males.

**Keywords:** Pelvic fracture, bridge fixation, spermatic cord

## Introduction

Pelvic fracture is a common fracture with a high incidence of widespread skeletal damage of 3% [1]. Pelvic ring injury is the result of high-energy trauma and is usually an unstable fracture [2-4]. Tile [5] confirmed that the anterior and posterior pelvic structures accounted for 40% and 60% of pelvic stabilization, respectively. To better stabilize pelvic fractures, it is necessary to combine anterior and posterior fixation.

Common methods for treating anterior pelvic ring fractures consist of external and internal fixation. The advantages of external fixation are little trauma and simple operation, but complications, such as pin tract infection, aseptic loosening, and local ulceration, can affect hip joint mobility and require inconvenient nursing care [6]. Internal fixation has become the preferred method for treating unstable pelvic fractures. However, the complex anatomical struc-

tures of the region, including important blood vessels, nerves, round ligaments, and the spermatic cord in males, are prone to iatrogenic injury and can lead to serious surgical complications [7].

In recent years, with technological developments and surgical innovation minimally invasive percutaneous internal fixation, which is associated with less trauma, reduced bleeding, easier execution, fewer complications and benefits to patient recovery, has become the mainstream method for the treatment of anterior pelvic ring fractures.

In 2012, Cole and colleagues were the first to report the minimally invasive percutaneous bridge fixation technique for treatment of the anterior pelvic ring [8]. The technique causes little trauma, is easy to perform and has few complications. However, with this technique, the spermatic cord is located under the plate,

## Modified technique of the Pelvic Bridge

**Table 1.** Patient characteristics

Patient	Age	Mechanism of injury	Tile type	Concomitant injuries	Operative time (min)	Blood loss (mL)	Matta criteria	Complications
1	27	Crush	B2	GUSI LLF	75	100	Good	
2	53	Fall	B2	LSPI	60	55	Excellent	
3	36	Fall	C1	LSPI	55	55	Excellent	PE
4	34	Fall	B1	Chest injury GUSI LLF	80	90	Good	
5	57	Fall	B1	Head injury	50	70	Excellent	
6	49	Fall	B2	LLF	60	65	Excellent	
7	47	Fall	B2	None	65	40	Excellent	
8	30	Fall	B2	Head injury LLF	65	45	Excellent	
9	40	Crush	C1	Chest injury Abdominal injury LLF	55	60	Excellent	
10	69	Traffic	C1	Chest injury	120	200	Poor	DVT UTI

GUSI, genitourinary system injury; LLF, limb or lumbar fracture; LSPI, lumbosacral plexus injury; PE, pulmonary embolism; DVT, deep vein thrombosis; UTI, urinary tract infection.

and because the anatomy of the inguinal canal and the spermatic cord is complicated and the spermatic cord is not fully revealed, there is the theoretical possibility of damage [9].

The purpose of this study was to introduce an improved surgical technique whereby after fully revealing the spermatic cord, the plate is inserted with the spermatic cord above the plate to avoid damaging the spermatic cord.

### Materials and methods

A retrospective analysis was performed to treat unstable anterior pelvic ring fractures from January 2015 to January 2018. Cases were included in the analysis: (1) Marvin Tile classification [5] of type B and C for unstable pelvic fractures and involvement of the anterior annulus, (2) patients undergoing modified minimally invasive percutaneous bridging fixation techniques, and (3) male patients.

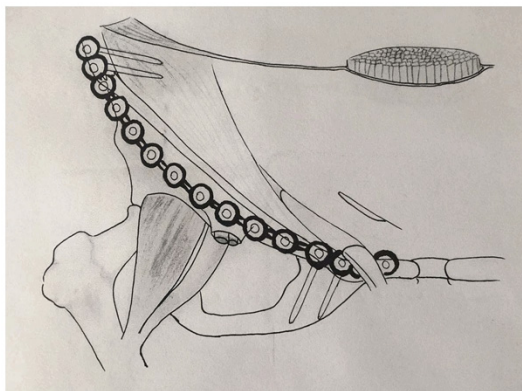
Throughout the study, a total of 15 patients underwent minimally invasive percutaneous bridging fixation of the anterior pelvic ring. Five of the patients were women. Eventually, 10 patients (**Table 1**) met the inclusion criteria. All patients underwent improved minimally invasive percutaneous bridging fixation techniques.

A retrospective analysis of patients with unstable anterior pelvic ring fractures treated from January 2015 to January 2018 was performed. The inclusion criteria were as follows: (1) patients with a Marvin Tile classification [5] of type B or C for unstable pelvic fractures and involvement of the anterior annulus; (2) patients undergoing treatment with the modified minimally invasive percutaneous bridge fixation technique; and (3) male patients.

Throughout the study, a total of 15 patients underwent minimally invasive percutaneous bridge fixation of the anterior pelvic ring. Five of the patients were women. In all, 10 patients (**Table 1**) met the inclusion criteria.

The average age of the 10 male patients was 44.2 years (range, 27-69). The mechanism of injury was as follows: fall from a height, 7 cases; crush injury, 2 cases; and traffic accident, 1 case. According to the Tile classification, there were 2 cases of B1, 5 cases of B2, and 3 cases of C1 fractures. Among them, the fractures were combined with other injuries in 9 cases, including head injury in 2 cases, chest injury in 3 cases, abdominal injury in 1 case, genitourinary system injury in 2 cases, lumbosacral plexus injury in 2 cases, and limb or lumbar fracture in 5 cases.

## Modified technique of the Pelvic Bridge



**Figure 1.** Schematic drawing showing the plate under the spermatic cord to prevent compression of the spermatic cord.

### *Surgical technique*

General anesthesia was used, and the anterior ring fracture was treated with the patient in the supine position. The anterior superior iliac spine (ASIS) was exposed obliquely by an incision approximately 3-5 cm in length. The pubic symphysis was exposed by a transverse incision approximately 6-8 cm in length. The ASIS incision was separated downward to the aponeurosis of the external oblique muscle. A periosteal screwdriver was used for blunt tissue dissection, and a subcutaneous tunnel was carefully created by hand in the superficial layer of the external oblique aponeurosis. The rectus abdominis at the pubic symphysis incision was separated. The traditional method involves inserting the plate into the subcutaneous tunnel and then inserting the screw without dissecting the spermatic cord and with the spermatic cord located under the plate. In the operation, the shallow ring of the inguinal canal was identified and the spermatic cord was dissected by gently pulling it with a rubber tube. Next, the plate was inserted and the spermatic cord was placed above the plate, screwed in the two ends of the plate with 2-3 screws, and then repaired the shallow ring of the inguinal canal (**Figures 1** and **2**). Then, drainage was placed, and the wound was sutured layer by layer.

### *Outcome evaluation indexes*

Outcome evaluation indexes, including the operative time, blood loss, quality of reduction

(Matta criteria) and complications, were recorded.

The Matta evaluation criteria [10] were used to evaluate the quality of pelvic anterior ring fracture reduction on X-ray films, with a fracture separation displacement < 4 mm considered excellent, 4~10 mm considered good, 10-20 mm considered fair, and > 20 mm considered poor.

Particular complications of our technique included iatrogenic spermatic cord injury and inguinal hernia. Other common complications included wound infection, nonunion, and fixation failure. Bed-related complications included urinary tract infection, deep vein thrombosis, and pulmonary embolism.

### *Statistical analysis*

All data were analyzed using SPSS v. 19.0 software (Chicago, IL, USA). The collected data are presented as the mean and SD.

### **Results**

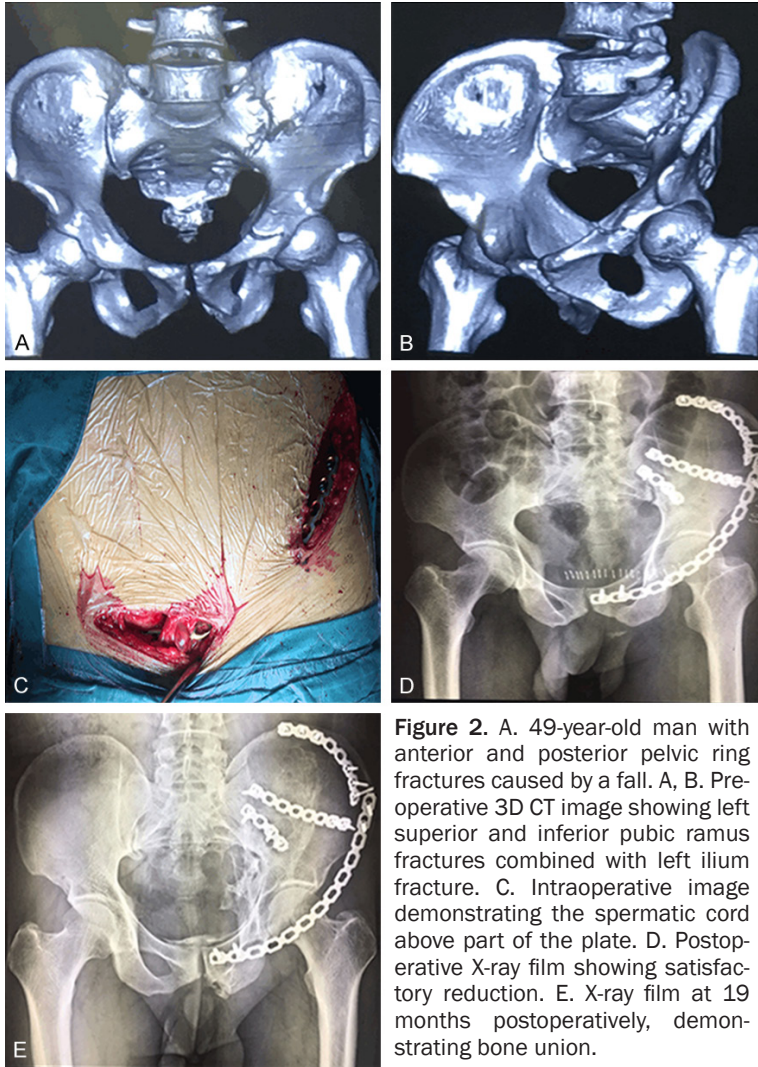
All 10 patients underwent treatment by anterior and posterior ring fixation. Unilateral anterior ring fixation was applied in eight patients, and bilateral fixation was applied in two patients. The average operative time was 68.5 minutes (range, 50-120), and the average volume of intraoperative blood loss was 78.0 ml (range, 40-200).

The quality of reduction was evaluated using the Matta criteria, as follows: excellent in 7 cases, good in 2 cases, fair in 0 cases, and poor in 1 case. The rate of excellent and good reduction was 90%. The only case of poor reduction was due to poor reduction of the posterior pelvic ring fracture, which is irrelevant to our technique.

All patients were followed for a mean duration of 12.1 months (range, 9-19). There were no instances of wound infection, nonunion or fixation failure.

Complications of the technique, i.e., iatrogenic spermatic cord injury and inguinal hernia, did not occur. Only one patient developed pulmonary embolism, and one patient developed deep vein thrombosis and urinary tract infection.

## Modified technique of the Pelvic Bridge



**Figure 2.** A. 49-year-old man with anterior and posterior pelvic ring fractures caused by a fall. A, B. Preoperative 3D CT image showing left superior and inferior pubic ramus fractures combined with left ilium fracture. C. Intraoperative image demonstrating the spermatic cord above part of the plate. D. Postoperative X-ray film showing satisfactory reduction. E. X-ray film at 19 months postoperatively, demonstrating bone union.

### Discussion

Minimally invasive percutaneous internal fixation, which offers less trauma, easier execution and fewer complications, has become the mainstream method for the treatment of anterior pelvic ring fractures [11]. Percutaneous pelvic anterior ring fixation techniques include fixation using percutaneous pubic screws [12], a percutaneous pelvic internal fixator (INFIX) [13, 14], and a percutaneous bridge [8]. Percutaneous pubic screw fixation carries the risk of internal fixation failure or injury to the adjacent important structures, such as the spermatic cord, nerves [15] and pelvic organs. Due to the complicated anatomy of the pelvis, it is possible to enter the hip joint when the pubic screw is inserted. Although the application of navigation technology can reduce certain risks, the requirements for the operator, hardware

and facilities are very high. Moreover, this surgical procedure cannot be applied in patients with an unsatisfactorily closed reduction, patients who are overweight or underweight, or patients with excessive pubic curvature. Studies in the literature on the INFIX device have reported high rates of complications [16], such as lateral femoral cutaneous nerve injury, femoral nerve palsy [17], and heterotopic ossification. Thus, care should be taken when treating anterior pelvic ring fractures with the INFIX device. In contrast, percutaneous bridge fixation has the advantages of a short learning curve, low operational difficulty, low requirements for hardware and facilities, less intraoperative radiation exposure, and a low complication rate.

Due to the lack of direct visualization with the minimally invasive percutaneous bridge fixation technique, some neurovascular structures, such as the lateral femoral cutaneous nerve, femoral artery and vein, femoral nerve and the round

ligament in females or spermatic cord in males, are theoretically at risk of being injured. Spermatic cord injury is the most catastrophic iatrogenic neurovascular complication that could occur during the surgical treatment of anterior ring fractures. The spermatic cord contains testicular arteries, a venous plexus, the vas deferens and their associated blood vessels, nerves and lymphatic vessels [18, 19]. A previous study reported that the average distance of the spermatic cord from the bridge plate was only 0.4 cm [20]. Thus, slight error could cause the plate to compress the spermatic cord, causing testicular necrosis in severe cases.

The anatomy of the inguinal canal and spermatic cord is complex, and there are anatomical variations. The most common anatomical variations include inguinal hernia and spermatic lipoma [21-25]. Furthermore, fracture displace-



ment can result in changes in the position of the spermatic cord. Sometimes, the steel plate could also compress the spermatic cord due to inappropriate shaping. If the spermatic cord is not fully revealed, and the steel plate is blindly placed above the spermatic cord, the spermatic cord may be damaged. Therefore, Reza et al. proposed routinely exposing the spermatic cord in pelvic anterior ring surgery [15].

Hence, careful dissection of the superficial inguinal ring to expose the spermatic cord was performed. Then, the spermatic cord was gently retracted, and the plate was inserted with the spermatic cord above the plate to avoid damaging the spermatic cord. There were no cases of iatrogenic spermatic cord injury or inguinal hernia. Although the inguinal canal was dissected in the series, no instances of inguinal hernia occurred, possibly due to our meticulous dissection because of our awareness of this complication.

Although the results of this work are very good, our research also has shortcomings. First, few cases were included. Second, as this study was a case review, there was no control group. The results require further confirmation by a comparative study with a large sample size.

### Conclusion

The need to dissect the spermatic cord in the series certainly prolonged the operative time and increased the volume of intraoperative blood loss. However, this technique prevents the possibility of the patient experiencing catastrophic complications.

A modified minimally invasive percutaneous bridge fixation technique avoids iatrogenic spermatic cord injury and thus offers a safe alternative method for the treatment of anterior pelvic ring fractures in males.

### Disclosure of conflict of interest

None.

**Address correspondence to:** Dian-Ying Zhang, Department of Orthopedics, The Fifth Central Hospital of Tianjin, Zhejiang Road 41, Binhai New Area of Tianjin, Tianjin 300450, China. Tel: +86-135010-20636; E-mail: zdy8016@163.com

### References

- [1] Polat A, Özkan E, Ülkü TK, Topaloğlu Ü. The relationship between pelvic (ring and acetabulum) fractures and organ injuries. *Eur J Orthop Surg Traumatol* 2012; 22: 35-9.
- [2] Wong JM, Bucknill A. Fractures of the pelvic ring. *Injury* 2017; 48: 795-802.
- [3] Balogh Z, King KL, Mackay P, McDougall D, Mackenzie S, Evans JA, Lyons T, Deane SA. The epidemiology of pelvic ring fractures: a population-based study. *J Trauma* 2007; 63: 1066-73; discussion 72-3.
- [4] Gabbe BJ, de Steiger R, Esser M, Bucknill A, Russ MK, Cameron PA. Predictors of mortality following severe pelvic ring fracture: results of a population-based study. *Injury* 2011; 42: 985-91.
- [5] Tile M. Pelvic ring fractures: should they be fixed? *J Bone Joint Surg Br* 1988; 70: 1-12.
- [6] Tucker MC, Nork SE, Simonian PT, Routt ML Jr. Simple anterior pelvic external fixation. *J Trauma* 2000; 49: 989-94.
- [7] Seyyed Hosseinzadeh HR, Eajazi A, Hassas Yeganeh M, Daftari Besheli L, Kazemi SM, Bigdeli MR, Okhovvatpoor MA. Modified ilioinguinal approach to the acetabulum and pelvis from beneath the inguinal ligament: a subinguinal approach. *Hip Int* 2010; 20: 150-5.
- [8] Hiesterman TG, Hill BW, Cole PA. Surgical technique: a percutaneous method of subcutaneous fixation for the anterior pelvic ring: the pelvic bridge. *Clin Orthop Relat Res* 2012; 470: 2116-23.
- [9] Reichel LM, MacCormick LM, Dugarte AJ, Rizkala AR, Graves SC, Cole PA. Minimally invasive anterior pelvic internal fixation: an anatomic study comparing pelvic bridge to INFIX. *Injury* 2018; 49: 309-14.
- [10] Matta JM. Indications for anterior fixation of pelvic fractures. *Clin Orthop Relat Res* 1996; 88-96.
- [11] Stevenson AJ, Swartman B, Bucknill AT. Percutaneous internal fixation of pelvic fractures. *Unfallchirurg* 2017; 120: 10-18.
- [12] Routt ML Jr, Simonian PT, Grujic L. The retrograde medullary superior pubic ramus screw for the treatment of anterior pelvic ring disruptions: a new technique. *J Orthop Trauma* 1995; 9: 35-44.
- [13] Kuttner M, Klaiber A, Lorenz T, Fuchtmeier B, Neugebauer R. The pelvic subcutaneous crossover internal fixator. *Unfallchirurg* 2009; 112: 661-9.
- [14] Vaidya R, Colen R, Vigdorichik J, Tonnos F, Sethi A. Treatment of unstable pelvic ring injuries with an internal anterior fixator and posterior fixation: initial clinical series. *J Orthop Trauma* 2012; 26: 1-8.

## Modified technique of the Pelvic Bridge

- [15] Firoozabadi R, Stafford P, Routt M. Risk of spermatic cord injury during anterior pelvic ring and acetabular surgery: an anatomical study. *Arch Bone Jt Surg* 2015; 3: 269-73.
- [16] Fang C, Alabdulrahman H, Pape HC. Complications after percutaneous internal fixator for anterior pelvic ring injuries. *Int Orthop* 2017; 41: 1785-90.
- [17] Hesse D, Kandmir U, Solberg B, Stroh A, Osgood G, Sems SA, Collinge CA. Femoral nerve palsy after pelvic fracture treated with INFIX: a case series. *J Orthop Trauma* 2015; 29: 138-43.
- [18] H G. *Gray's Anatomy*: Philadelphia: Lea &Febiger; 1985.
- [19] Raman JD, Goldstein M. Intraoperative characterization of arterial vasculature in spermatic cord. *Urology* 2004; 64: 561-4.
- [20] Moazzam C, Heddings AA, Moodie P, Cole PA. Anterior pelvic subcutaneous internal fixator application: an anatomic study. *J Orthop Trauma* 2012; 26: 263-8.
- [21] Carilli S, Alper A, Emre A. Inguinal cord lipomas. *Hernia* 2004; 8: 252-4.
- [22] Heller CA, Marucci DD, Dunn T, Barr EM, Houang M, Dos Remedios C. Inguinal canal "lipoma". *Clin Anat* 2002; 15: 280-5.
- [23] Irwin T, McCoubrey A. Adult groin hernias. *Surgery (Oxford)* 2012; 30: 290-5.
- [24] Lilly MC, Arregui ME. Lipomas of the cord and round ligament. *Ann Surg* 2002; 235: 586-90.
- [25] Nasr AO, Tormey S, Walsh TN. Lipoma of the cord and round ligament: an overlooked diagnosis? *Hernia* 2005; 9: 245-7.