# RESEARCH



# Anterior subcutaneous internal fixator (INFIX) versus plate fixation for anterior ring injury in Tile C pelvic fractures: a retrospective study

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# Abstract

**Objectives** . The purpose of this study was to compare the reduction effect and clinical outcomes of anterior subcutaneous internal fixation (INFIX) and steel plate-screw internal fixation in the treatment of anterior ring injury in Tile C pelvic fractures.

**Methods** . In this retrospective study, the clinical outcomes of 46 patients treated using INFIX and 44 patients treated with steel plate-screw internal fixation were analyzed and compared. All patients underwent anterior and posterior fixation. The Matta imaging scoring system was used to evaluate the postoperative reduction accuracy; the Majeed scoring system was applied to obtain functional outcomes in clinical follow-up. All potential complications were identified and evaluated accordingly.

**Results** Both groups of patients were followed up for a period of 13–36 months, with an average of 27 months. The procedure time and blood loss in the INFIX group were significantly lower than those in the plate group(t = -2.327, P = 0.023;t = -4.053, P = 0.000; there was no statistically significant difference in the Majeed score and Matta score between the two groups after surgery (P > 0.05).

**Conclusions** . INFIX treatment for anterior ring injury in Tile C pelvic fractures can achieve good therapeutic effects. Compared to internal fixation with plates and screws, it has advantages such as shorter surgical time and less blood loss. INFIX may be more suitable for obese patients, young women of childbearing age, or patients with urinary system injuries.

Keywords INFIX, Pelvic fracture, Internal fixation, Anterior ring injury, Tile C pelvic fractures

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# Introduction

Pelvic fractures account for 2–8% of total body fractures, often caused by high-energy trauma such as high fall injuries and road traffic accidents; it's usually associated with concomitant injuries, resulting in complex conditions [1]. Due to the high disability and mortality rates of pelvic fractures, they impose a great burden on society and therefore require active treatment [2]. The pelvic ring can be divided into anterior and posterior rings. Although the posterior ring provides the main stability (60%), the anterior ring still accounts for 40% of its stability [3]. Tile classification is based on the stability of pelvic fractures, in which Tile C pelvic fractures are vertically and posteriorly unstable, often requiring simultaneous fixation of the anterior and posterior rings [4].

External fixation is commonly used as the initial and temporary stable treatment for anterior ring injuries in pelvic fractures [5]. It can be quickly placed and easily stabilize the injured pelvic ring, achieving the goal of reducing pelvic bleeding. However, many studies have reported clinical complications related to external fixation stents, including pin tract infections, screw loosening, loss of reduction [6, 7, 8, 9]. Moreover, external fixation stents also have the disadvantage of affecting patient mobility and compressing the abdomen of obese patients.

The anterior subcutaneous internal fixation (INFIX) is based on the same principle as the double screw external fixation (EXFIX), but uses subcutaneous application. It is harder than standard external fixators, eliminating open pins bundles, thereby improving patient comfort and care. It was originally designed as an alternative to external fixation for obese patients, but later it was used for a wider range of patients [10, 11]. There is also extensive research on INFIX in the field of biomechanics; McDonald et al. [12] revealed that INFIX has good resistance to axial displacement and separation in the treatment of vertically and rotationally unstable pelvic ring injuries; Vaidya et al. [10] reported that the fixation strength of INFIX is better than that of external fixation, and the fixation strength can be increased by 23%; On the basis of INFIX, Wang [13] implanted an additional screw in the pubic branch to increase the stability of fracture fixation and reduce the occurrence of pain above the pubic bone.

There are still few reports comparing the efficacy of INFIX and anterior plate fixation. Therefore the purpose of this retrospective study is to compare the reduction effect and clinical outcomes of INFIX and steel plate fixation in the treatment of anterior ring Tile C pelvic fractures by evaluating postoperative reduction imaging, functional outcomes, and related complications.

# **Materials and methods**

The study was approved by the Institutional Ethical Committee in West China Hospital of Sichuan University and written informed consent was obtained from all patients. We retrospectively identified a series of patients with Tile C pelvic fractures who underwent surgery by our team between January 2019 and January 2023. The main inclusion criteria were the radiological diagnosis of Tile C pelvic fracture requiring anterior fixation, patients managed operatively. The exclusion criteria included open fracture with contaminated wound, pathological fracture, and those patients who were lost in follow-up. All cases were confirmed by a combination of history, clinical examination, X-ray and CT scan. Two experienced orthopedists and coauthors of the current study evaluated the imaging data and classified each fracture using the Tile classification [4] protocol.

### Surgical procedure

All patients received general anesthesia and were positioned in supine position on a radiolucent operating table. Posterior pelvic ring injury was addressed as the priority of fixation if needed (in patients with associated sacroiliac joint disruption). Anterior ring fixation was performed after the stabilization of the posterior ring.

For patients with posterior ring injury (in Tile C-type pelvic fractures), we preferentially use sacroiliac screw fixation. The specific surgical steps are as follows: patients were placed in a supine position, and the entry point for the screw was precisely located under the guidance of a C-arm X-ray machine. Subsequently, a guide pin was inserted along the predetermined direction to ensure that it passes through the cortical layer of the iliac bone, the sacroiliac joint, and into the S1 vertebra. After measuring the depth of the guide pin, a hollow drill was used to create a hole, and a 6.5 mm hollow screw of appropriate length was used to complete the fixation.

In the INFIX group, a 2-3 cm oblique incision was made on both sides with the anterior inferior iliac spine (AIIS) as the center. Directly separate the muscle gap between the tensor fascia lata and the sartorius muscle to expose AIIS. Two thyroid hooks are used to pull and open soft tissues, avoiding damage to nerves and blood vessels. When inserting the starter, pay attention to 70 ° backward and 30 ° inward. The probe should be inserted from the entry point towards the posterior superior iliac spine (PSIS) to avoid penetrating the acetabulum; Approximately 2 cm near the upper edge of the acetabulum; The guiding component should be determined under fluorescence after insertion. The awl should be completely inside the bone above the greater sciatic notch. Secondly, use a threaded drill to expand the bone canal along the guide wire, use a probe to confirm the integrity of the four walls of the bone canal, and drill about 60-80 mm pedicle screws into the bone canal. Insert the multi axis pedicle screw (diameter 7.5 mm, length 70 mm) into the pre drilled screw tube; Maintain a distance of at least 2 cm between the pedicle screw head and the bone surface to avoid compressing vascular tissue after installing the connecting rod. Afterwards, a subcutaneous tunnel is formed above the superficial surface of the deep fascia; Insert a curved titanium rod (diameter 5 mm) through a subcutaneous tunnel to connect bilateral pedicle screws. Tighten both sides of the end cover with a screwdriver. Then, use two overlapping fingers to check if there is enough space between the rod and the bone. A typical case is shown in Fig. 1.

In the ORIF (open reduction and internal fixation) group, the pubic symphysis plate is inserted through the Pfannenstiel approach or the modified Stoppa approach. We recommend using a 4–6 holes 3.5 mm reconstruction plate placed above the pubic symphysis, with the second plate placed in front of the pubic symphysis to enhance stability if necessary. A typical case is shown in Fig. 2.

It should be remembered that, cases reporting pubic symphysis disruption with associated superior pubic rami fracture may present transpubic instability; if so, they should be considered as candidates for additional fixation using 3.5–4.5 mm cortex screw, placed into the pubic ramus to supplement the function of the pubic symphysis plate and increase the strength of the internal fixation; the cortex screw length should be enough to cross the corresponding fracture line; additionally, care should be taken not to penetrate the hip joint cavity. If there is only unilateral or bilateral pubic ramus fracture and there is no pubic symphysis loss, traditional plate screws are used through the modified Stoppa approach instead of pubic symphysis screws.

### Postoperative follow-up and assessment

The patients were followed up regularly at 1, 2, 3, 6 months and one year after surgery and yearly thereafter. Majeed grading scale was used to evaluate the postoperative functional outcome [14]. The aggregate score was classified as excellent (>85), good (70–84), fair (55–69), or poor (<55).

# Statistical analysis

Statistical analyses were conducted using SPSS 25.0 software (SPSS Chicago, IL, USA). The statistical methods adopted included frequency, percentage (%), mean, t test, Mann-Whitney U test, Fisher's exact test, and Pearson's chi-squared test. A value of p < 0.05 was considered as statistically significant difference.

# Results

This study included 90 patients with anterior ring Tile C pelvic fractures treated with INFIX or internal fixation with plates and screws in our department. Among them, 46 patients were treated with infix and 44 patients with plate. The average age and gender distribution between these two groups was not statistically significant (p > 0.05). These two groups were similar in ISS, their



Fig. 1 (A) Pelvic AP view of a Tile C1.3 pelvic ring injury; (B, C) Pelvic inlet and outlet view of an Tile C1.3 pelvic ring injury; (D)Preoperative three-dimensional computed tomography reconstruction; (E, F, G) Pelvic AP, inlet and outlet view one year after surgery, INFIX technique was used for anterior ring injury, and sacroiliac screws were used for posterior ring injury; (H) Patient's functional phase one year after surgery



Fig. 2 (A, B, C) Pelvic AP, inlet and outlet view of a Tile C1.2 pelvic ring injury, Combined left femoral head necrosis; (D) Preoperative three-dimensional computed tomography reconstruction; (E, F, G) Pelvic AP, inlet and outlet view one year after surgery, the anterior ring is fixed with open reduction pubic symphysis double steel plates, while the posterior ring is fixed with sacroiliac screws; (H) Postoperative three-dimensional computed tomography reconstruction

# Table 1 Patient characteristics of two groups

Characteristics	INFIX	Plate	Р
	group( <i>n</i> = 46)	group( <i>n</i> =44)	value
Age(yrs.)	39(18,68)	37.5(18,68)	0.728
Gender: male/female	22/24	26/18	0.284
ISS <sup>a</sup>	29(17,41)	27(18,41)	0.067
Injury mechanism			
Fall from height	18	18	
Traffic accident	26	22	
Other	2	4	
Time to surgery(d)	7(1,28)	5.5(2,33)	0.482
Procedure time(min)	185.4±48.9	$218.6 \pm 28.7$	0.021
Blood loss(ml)	232.2±119.1	340.9±135.2	0.000
Type of Fixation for Posterior			
Pelvic Ring Fractures			
Minimally invasive screws	32	31	
Plate	10	8	
Nail rod system	4	3	
Type of Anterior Ring Fracture			
Unilateral pubic ramus	13	11	
fracture	19	14	
Bilateral pubic ramus	8	6	
fractures	6	13	
Pubic symphysis			
separation			
Pubic symphysis separa-			
tion combined with pubic			
ramus fracture			
ISS, injury severity score			

 Table 2
 Postoperative radiology and functional outcome arading

	INFIX	Plate	Р
	group( <i>n</i> = 46)	group( <i>n</i> =44)	value
Tornetta and Matta			
grading			
Excellent	19	23	
Good	16	13	
Fair	9	7	
Poor	2	1	
Satisfactory rate	35/46(76.09%)	36/44(81.81%)	0.511
Follow up time(month)	26(13,36)	33(13,36)	0.071
Majeed score	$85.67 \pm 5.11$	$86.89 \pm 6.04$	0.306
Pain	25(25,30)	25(25,30)	0.730
Work	16(12,20)	16(12,20)	0.762
Sitting	10(8,10)	10(6,10)	0.007
Sexual intercourse	4(3,4)	4(4,4)	0.160
Standing	10(10,12)	12(10,12)	0.174
Gait unaided	10(8,12)	10(8,12)	0.412
Walking distance	10(8,10)	10(8,12)	0.113
Standing Gait unaided Walking distance	10(10,12) 10(8,12) 10(8,10)	12(10,12) 10(8,12) 10(8,12)	0.174 0.412 0.113

Postoperative radiographic reduction grading revealed that the two groups had a similar satisfactory rate (("Excellent"+"Good")/total number of patients)) (76.09% vs. 81.81%, p = 0.511). The median follow-up was 26 months (range 13–36) in the INFIX group and 33 months (range 13–36) in the plate group (p = 0.071). There was no significant difference in Majeed score between INFIX group and plate group (p > 0.05), however the difference in sitting score was statistically significant (t = -2.785, P = 0.007) (Table 2).

mechanism of injury and time to pelvic surgery (p > 0.05) (Table 1).

The INFIX group was superior to the plate group in terms of procedure time and blood loss (t = -2.327, P = 0.023;t = -4.053, P = 0.000).

### Complications

Twelve (26.09%) patients who underwent INFIX placement suffered LFCN paralysis. Its symptoms mainly manifested as anterolateral skin numbness of the affected thigh. Most patients stated that their symptoms gradually disappeared within three months after following the course of treatment with mecobalamin. Seventeen (36.96%) patients developed heterotopic ossification; however, all of them were asymptomatic. Four cases (8.70%) of superficial infection occurred, and was related to the poor soft tissue condition at the surgical site; all patients' condition resolved using oral antibiotics.

In the plate group, seven (15.91%) patients developed asymptomatic heterotopic ossification. The infections in the plate group occurred in two (4.55%) cases with bladder or urethral disruptions. Both patients achieved wound healing after debridement, oral antibiotics and continuous dressing changes.(Table 3).

# Discussion

The purpose of Tile C pelvic fracture fixation is to restore the integrity and stability of the pelvic ring, which usually requires the fixation of the anterior and posterior pelvic rings [15]. Sacroiliac screw and pubic symphysis dual plate fixation have mechanical advantages, providing maximum mechanical stability to the pelvic ring. There are several anterior and posterior ring fixation methods [16, 17, 18]; however, the best treatment method is still controversial, nevertheless, minimally invasive techniques has gradually become a trend [19]. The present study compared the reduction effect and clinical outcomes of INFIX to ORIF with plate-screw in the treatment of Tile C pelvic fracture with anterior ring disruption; the study proved that INFIX protocol mininized soft tissue trauma in the treatment anterior ring disruption, and shorter operation time compared to ORIF, while there was no significant difference in reduction effect and clinical outcomes between both groups.

External fixator has been widely used as an effective anterior ring fixation tool. However, it is associated with complications, such as pin tract infection, aseptic loosening, and loss of reduction [6, 7, 8, 9]. In 2009, Kuttner et al. [20] first reported the use of pedicle screw-rod system in 19 patients to fix anterior ring fractures. Vaidya et al. [10] referred to the method of percutaneous fixation of anterior pelvic ring with screw rod system as INFIX technology, which was gradually popularized and applied in the course of recent years in clinical practice.

In the current study, the blood loss and procedure time in the INFIX group were significantly lower than those in the plate group. The main reason was that INFIX could be implanted subcutaneously, while the plate group needed to expose the fracture site and restore the fracture to the original anatomical structure; this finding was

Table 3 Complications of two groups

	INFIX group(n = 46)	Plate group(n = 44)		
LFCN paralysis	12(26.09%)	0(0%)		
heterotopic ossification	17(36.96%)	7(15.91%)		
superficial infection	4(8.70%)	2(4.55%)		

previously supported in literature by some authors [21]. Anatomic study found that INFIX fixation can effectively avoid important blood vessels, nerves and reproductive structures, thus reducing the damage to the corresponding tissues/organs, reducing postoperative infection and inflammation [22]. INFIX technology has the advantages of shorter procedure time, limited soft tissue trauma and reduced blood loss. When establishing subcutaneous channels, the incidence of soft tissue traction injury and thrombosis can be significantly reduced, avoiding disruption of blood supply to the fracture site during operation, which is conducive to enhance postoperative healing [23]; There is no need for accurate reduction before operation, and the treatment options for patients with large displacement, and comminuted fractures are more flexible and diverse.

In this study, it was found that there was no statistical difference in the Matta and Majeed score of postoperative functional recovery, suggesting that the two treatments have their own advantages, both of which can increase the stability of the anterior pelvic ring and promote postoperative functional recovery. According to the literature, INFIX forms a triangular geometrical figure, through the placement of pedicle screws, with the original structure of the pelvis. Additionally, it connects the fixation points through connecting rods to simulate the physiological reconstruction of the anterior ring, making its biomechanical performance infinitely close to the normal physiological structure, enhancing stability and strong fixation [24].

In the follow-up of the INFIX group, patients with lower Majeed score often reported that they had abdominal discomfort during body position change. Such patients are mostly skinny, while obese patients usually did not have this feeling, suggesting that obese patients may benefit more from infix.

According to some studies, the common complications of anterior ring injury of pelvic fracture fixed with infix include lateral femoral cutaneous nerve injury, heterotopic ossification, femoral nerve paralysis, infection [25, 26]. The most important complication is lateral femoral cutaneous nerve injury. According to statistics, the incidence is as high as 27%; the main symptoms are numbness or paresthesia of the anterolateral thigh skin following surgery, but it is usually self-limiting [13, 27, 28, 29]. In the current study, 12 patients in the INFIX group experienced this complication and recovered after oral methylcobalamin. Exposure and traction during surgery can stimulate the injury of the lateral femoral cutaneous nerve, and it is recommended to appropriately lengthen the incision, carefully dissect, and correctly identify the nerve to reduce the occurrence of this complication. Hoskins et al. [25] reported a prospective study involving 21 patients, in which 12 cases (57.1%) experienced symptoms of lateral femoral cutaneous nerve injury after surgery, which was much higher than other reported results [21, 30]. The analysis and study were related to the use of pedicle screws with a diameter of 10 mm. Therefore, in this study, screws with a diameter of 7.5 mm are generally selected, and selecting screws with an appropriate diameter is an effective measure to reduce the incidence of complications.

In addition, femoral nerve injury is also one of the complications of INFIX. As this complication often leads to functional impairment in patients, even after removal of the internal fixation, it is difficult to fully recover. Therefore, it should be taken seriously. A multicenter retrospective study by Hesse et al. [30] reported 6 cases of femoral nerve paralysis after INFIX surgery, suggesting a possible association with increased pressure in the iliopsoas and groin muscles. Increasing the curvature of the connecting rod can effectively reduce the possibility of tissue compression under the rod.

This study indicate that INFIX can be used for the treatment of anterior pelvic ring fractures, especially for patients with obesity or multiple injuries and minimal displacement of anterior pelvic ring fractures.

However, the current study is not without limitations. Firstly, the selection of surgical techniques is exclusively at the discretion of the operating surgeon. Although there was no statistically significant difference in ISS scores between the two groups of patients, in those with high ISS scores, we prefer to apply INFIX in case of mild pelvic fractures and other severe injuries to reduce intraoperative trauma; we are aware that this can lead to result bias; Secondly, the sample size of this study is relatively small and is a single center retrospective study. The next step is to expand the sample size and conduct a multicenter prospective study to further compare the efficacy of the two internal fixation methods.

# Conclusions

INFIX is relatively minimally invasive and time-saving than the reconstruction plate for the treatment of anterior pelvic ring fractures. INFIX for anterior ring injury Tile C-type pelvic fractures can achieve good therapeutic effects. Compared with internal fixation with steel plates and screws, it has advantages such as shorter surgical time and less intraoperative bleeding. INFIX is particularly suitable for obese patients.

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### Author contributions

Conception and study design: S.B.H and S.H; acquisition of data: S.B.H, S.H, G.R.K, and Y.J.Y; analysis and interpretation of data: S.B.H, G.R.K., S.H and Y.J.Y; drafting of the manuscript: S.B.H, S.H and Y.Y; critical revision: Y.Y and Y.F. All authors reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the study.

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### Data availability

The datasets generated during the current study are available from the corresponding author on reasonable request.

### Declarations

### Ethics approval and consent to participate

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee at the West China Hospital of Sichuan University and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Given to the retrospective nature of this study, the informed consent was waived.

### **Consent for publication**

Not applicable.

### **Competing interests**

The authors declare no competing interests.

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