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Minimally-Invasive Treatment for Anterior Pelvic Ring Disruption with Pedicle Screw–Rod Fixation (Infix Technique): An Initial Case Series

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Abstract

Objective: To evaluate the clinical application of the minimally-invasive pedicle screw–rod fixator (INFIX) for anterior pelvic ring disruption: feasibility, applicability, and limitations.

Design: Retrospective cohort study.

Setting: Chinese Army General Hospital PLA, a tertiary care hospital in Beijing, China.

Patients/Participants: 28 patients with pelvic injuries between May 2012 and August 2016.

Intervention Underwent definitive anterior fixation using the minimally-invasive INFIX technique with or without posterior fixation.

Main outcome measurements: Injuries were classified using the Young and Burgess, and Tile classification systems. Reductions of the pelvic ring were assessed using the Matta criteria. Patients were contacted to obtain functional outcomes using the Majeed scoring system, Complications were tabulated.

Results: The range of follow-up was 12-38 months post-surgery. The quality of fracture reduction was excellent in 15 patients, good in nine, and fair in four. The mean Majeed functional pelvic score was 80.65 ± 14.2 (median 84, range 51 to 100). Six had injury to the Lateral Femoral Cutaneous Nerve (LFCN), and two suffered painful implant impingement. Asymptomatic heterotopic ossification occurred in eight patients. There were no patients with deep vein thrombosis, intra-abdominal violations or infection.

Conclusion: INFIX is a reliable, simple, safe, and mini-invasive approach for stabilizing unstable anterior pelvic injuries.

Keywords: Pelvis fracture; Internal fixation; Minimal invasive surgery; INFIX

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Background

Pelvic fractures constitute only 0.3% to 6.0% of all fractures, but they are usually severe and life-threatening injuries complicated by hemorrhagic shock, and/or multiple organ injuries [1]. Surgeons widely agree that early reduction and fixation of unstable pelvic ring injuries should be performed restore pelvic stability and reduce potential complications. Current options for treatment include pelvic circumferential wrapping of the pelvic region with a sheet or strap [2,3], binding [4], inflatable pneumatic trousers [5], external fixation [6-9], closed reduction with percutaneous fixation [10], and Open Reduction with Internal Fixation (ORIF) [11-14]. The purpose of surgery is to reduce pelvic volume in order to minimize retroperitoneal hematoma and to stabilize the fracture. For anterior pelvic instability, the external fixation (Ex-Fix) with mini-invasive approach has been successfully applied for temporary and/or final stabilization of many unstable pelvic injuries. However, the technique is often complicated by infection, discomfort, and difficulty for caregivers, particularly in obese patients [12,15-17]. Successful treatment of unstable pelvic ring injuries remains a challenge for orthopedic surgeons.

The INFIX, or "Pelvic Bridge", a new technique that employs the principles of external fixation, was initially developed for use in obese patients. The technique involves implant subcutaneous placement of the implant in order to avoid the risk of pin tract infection, as well as to maintain the mini-invasive features of external fixation. Vaidya R et al. [21]. First reported the technique

for stabilizing unstable pelvic fractures using supra-acetabular spinal pedicle screws and a subcutaneous connecting rod (INFIX). Gardner MJ et al. [16] demonstrated that this fixation avoids many of the drawbacks of traditional anterior pelvic external fixation, such as pin-tract infection and limitation of patient mobility [18,19].

INFIX has been successfully used in our hospital over the past five years. Biomechanical studies have shown that minimally-invasive INFIX gives superior stability to external fixation, because of the shorter lever arm of the construct [20]. However, some studies have shown a higher rate of complications, in particular LFCN palsy and heterotopic ossification [19]. The aim of this study is to evaluate the clinical application of the minimally-invasive pedicle screw-rod fixator (INFIX) for anterior pelvic ring disruption, including its feasibility, applicability, and limitations.

Patients and Methods

Between May 2012 and August 2016, 28 patients with pelvic injuries underwent definitive anterior fixation using the minimally-invasive INFIX technique described by Vaidya R [21]. A tertiary care hospital in Beijing. The inclusion criterion was a rotationally-unstable pelvic ring injury requiring anterior fixation, including pubic ramus fractures and symphyseal diastasis. Exclusion criteria were as follows: hemodynamic instability making patients unsuitable for surgery within 3 weeks; infection or soft tissue defects preventing coverage of the fixation; and acetabular or supra-aceta bular fractures that impaired the stabilization of screw insertion. All patients required AP and inlet and outlet pelvic radiographs to fully evaluate the displaced pelvic ring injuries. Three-dimensional pelvic computed tomography scans were performed as well. Preoperatively, we evaluated the severity of the injuries using the Injury Severity Score. All patients were treated with preoperative ipsilateral skeletal or external traction to contribute to fracture reduction. Surgery was scheduled as early as the patient's physiological condition allowed. The average time from injury to surgery was 4.5 days (range, 2 days to10 days).

The Surgical Technique

The patient was positioned supine on a flat radiolucent table. The pelvis was widely prepared and draped in regular sterile fashion. If required, stabilization of the posterior pelvic ring was achieved prior to application of the INFIX. For application of the INFIX, a longitudinal 3-cm incision was made lateral to the space between the sartorius and Tensor Fascia Lata (TFL). The fascia was incised and blunt dissection was performed to the anterior inferior iliac spine (AIIS) to protect the Lateral Femoral Cutaneous Nerve (LFCN). A bony safe tunnel for the screws was opened toward the PSIS by a starting pedicle awl and a finder. Fluoroscopy Judet views were used to confirm accurate placement. A polyaxial pedicle screw, 60 mm to 80 mm in length and 6.5 mm or 7.0 mm in diameter was then inserted in the tunnel for adequate depth. Importantly, the screw head was fixed roughly 2 cm proud of the bone. Further along on the contralateral side, a similar screw was introduced. A 6.0 mm long titanium rod was contoured and placed subcutaneously. The rod was connected to the screw heads and locked at one end. Reduction of the anterior ring was achieved by lateral compression and, if necessary, by leg traction and internal rotation prior to locking of the remaining screw head. After surgery, all patients performed functional exercises of the lower limbs and joints in bed without weight bearing. Patients were allowed to sit at 2-weeks postoperatively and gradually begin walking with full weight bearing at 3 months, when postoperative radiographs demonstrated

Figure 1A: 64-year-old female patients. Postoperative radiograph of the pelvis shows stabilization of the bilateral anterior pelvic ring fracture was performed by pedicle screw–rod fixation (INFIX technique).

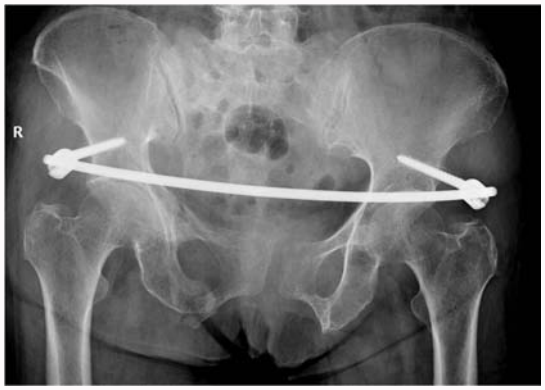

Figure 1B: Same patient as Figure 1. Radiograph of the pelvis 6 months postoperatively shows fractures healed.

Figure 1C: Same patient as Figure 1a. Radiograph of the pelvis after hardware removed.

progressive callus formation. The implant was removed at an average of 6 months postoperatively (range, 4 months to12 months). Pelvic ring injuries were considered healed if patients could bear weight comfortably without further displacement of their pelvis.

To evaluate the technique's feasibility, applicability, and limitations, a retrospective cohort study was performed using our hospital's trauma database. Medical records and radiographs were reviewed and the following information was recorded: age, gender, fracture classifications, Injury Severity Score (ISS), date of initial surgery, date of implant removal when applicable, most recent

Figure 1D: The patient suffered complication of LFCN injury on both sides after surgery.

follow-up, method of injury, associated injuries, outcome scores, and complications. Pelvic injuries were graded separately by two attending physicians using the Tile as well as the Young and Burgess classification systems [22,23]. AP radiographs (XR) were used in conjunction with CT scans and exam to classify the fractures. Patients were followed by phone or in clinic and assessed for functional outcomes using the Majeed score [24]. The presence of Heterotopic Ossification (HO) was evaluated by radiographs taken within one month of INFIX removal. Reductions of the pelvic ring were assessed using the Matta criteria [25].

Statistical Methods

All data were analyzed by SPSS 17.0 software (PSAW Statistics, IBM, USA). Quantitative data was expressed as mean ± SD values. Qualitative data and ratio variables were expressed as percentiles (%).

Results

Patients included 13 males and 15 females with an average age of 42 years (range, 18 years to 83 years). Twelve patients were involved in motor vehicle crashes, seven were pedestrians struck by automobiles, five fell from heights, and four were involved in a motorcycle crash. The mean Injury Severity Score (ISS) was 31 ± 5 (range, 16 to 50). Sixteen of the pelvic injuries were unilateral and twelve were bilateral. According to the Tile classification, 22 injuries were C-type injuries, and 6 cases were B-type (Shown in Table 1). In six patients, only the anterior subcutaneous pedicle screw-rod fixator (INFIX) was used. In 22 patients, INFIX was combined with posterior fixation. In 22 patients, implants were removed at an average of 5 months postoperatively (range, 3 months to 8 months). Heterotopic ossification at the screw heads was seen in eight patients. Temporary neuropraxia of the lateral femoral cutaneous nerve occurred in six patients, with complete resolution following implant removal. No patient developed a deep infection. Two patients reported rod irritation (Table1). All patients were at stage-one healing prior to discharge: able to sit, stand, and roll on their sides. All patients were followed-up for an average of 20.1 months (range, 12 months to 38 months) following surgery. The quality of fracture reduction was excellent in 15 patients, good in 9, and fair in 4. Mean of Majeed functional pelvic score was 80.65 ± 14.2 (median 84, range 51 to 100).

Discussion

High-energy unstable pelvic ring injuries frequently involve disruption of anterior and posterior bony and/or ligamentous structures. The anterior and posterior ring provides 30% and 70% of pelvic stability, respectively. Anterior pelvic external fixation is a common method for supplementing posterior fixation [26]. Complications of the procedure include pin tract infection, osteomyelitis, aseptic loosening, restricted activities, and nerve damage [27]. Mason et al. [15] reported on 52 patients whose pelvic ring injury was treated in part by definitive anterior external fixation. Of these, 50% developed a pin site infection, 12% required premature removal for infection, and 17% required revision as a result of pin loosening or loss of reduction. The overall complication rate resulting from the anterior pelvic external fixator was 62% [21]. To avoid these complications, a novel technique was developed for internally stabilizing the anterior pelvic ring [21,28]. Kuttner M et al. [28] first reported surgical use of a pedicle screw-rod fixator for treatment of anterior pelvic ring fractures in 2009 [28].

Vaidya R et al. [29] described a modified technique for treatment of unstable pelvic ring injury, which they named INFIX [21]. The technique has been reported to provide good clinical outcomes, including: good tolerance, low morbidity, low wound complication rates, and the provision of stability equivalent to other techniques. INFIX minimizes the possibility of pin tract infection and long-term discomfort, especially in obese patients. Our study showed that no skin infection occurred, even in those patients at risk for groin or thigh wound infections. In our series, one patient who suffered a rectal tears and groin myofascial necrosis achieved successful fracture union. He had no complications 3 months following. No wound complications were seen with the subcutaneous fixator. Compared with ORIF, this technique is minimally-invasive. Patients have only two small incisions on both AIIS area without major dissection or blood loss. In a case control study, Vaidya R et al. [29] found that INFIX gave similar outcome scores and fewer complications, despite the fact that open plating provide better reduction of the pubic symphysis [29].

In the present study, we report the outcome of patients with unstable pelvic fractures treated with subcutaneous-external fixation. The average Majeed score of our patients was 80.6. Among the patients with full-time jobs, 66% returned to work following treatment. INFIX was suggested as treatment of their injuries, as it avoids the use of extensive approaches, minimizes bleeding, gives fewer wound complications, and avoids prolonged surgery. Better outcomes were achieved at follow-up.

INFIX has been biomechanically demonstrated to be a reliable approach to stabilize unstable anterior pelvic injuries [20,30,31]. In one study using a single-stance pelvic fracture model, INFIX gave better stiffness than external fixation at both the pubic symphysis and sacroiliac joint [30]. Another study showed that INFIX gave similar translational and superior rotational stiffness of in vitro mechanical stability compared with external fixation [20].

The type of pedicle screw determines the performance of INFIX. In a biomechanical study, monoaxial screws provided substantially greater stiffness than did polyaxial screws. Polyaxial INFIX did not give greater stiffness than traditional external fixation despite the mechanical advantage of being closer to the bone [31]. However, polyaxial screws have been suggested to reduce the difficulty of rod manipulation. In the present study, there were no cases of loss of fixation, although we chose poly axial screws. There was also evidence that the anterior internal fixator provided indirect compression along the sacroiliac joints, which can be beneficial when acute stabilization of the posterior pelvic ring is contraindicated [32]. Monoaxial screws

Table 1: Demographics, Fracture Classifications and Complications.

Patient	Age	Sex	Fx class	Associated injury	Complication
1	75	F	Tile B, APC	Viginal tear, hemorrhageic shock	LFCN irritation
2	18	M	Tile C, APC	Lt distal radial fx, navicular fx, hemoperitoneum	HO
3	49	M	Tile C, CM	Rectal tear, hemodynamic instability, cercical spine fx, Lt femur fx, L5 fx, Lt 2nd metacarpal fx	LFCN irritation
4	56	F	Tile C, LC	Rt scapular fx, head injury, L4 fx, L5 fx, Rt proximal tib fx	HO
5	51	F	Tile C, LC	head injury, Rt tibofibular fx	rod irritation
6	45	F	Tile C, LC	Lt ulna shaft fx, head injury, intracranial contusion	LFCN irritation
7	25	F	Tile C, LC	None	HO
8	26	F	Tile C, APC	L5 fx, brain contusion, Lt brachial plexus injury, Lt Acetabular fx	HO
9	83	M	Tile C, LC	Lt supracondylar femur fx	
10	51	M	Tile C, LC	Rt intertrochanteric fx, Lt tib fib fx, Rt calcaneous fx and subtalar subluxation	LFCN irritation
11	19	F	Tile C, LC	None	
12	49	F	Tile C, LC	L3-5 fx	HO
13	49	M	Tile C, CM	L5 fx, Rt acetabular fx, Bladder disruption, hemodynamic instability	HO
14	28	F	Tile B, LC	None	
15	25	M	Tile C, VS	Lt ulna shaft fx, Lt radial head dislocation and col ligament rupture	
16	64	F	Tile C, LC	head injury, L4 fx, L5 fx,	LFCN irritation
17	19	F	Tile B, LC	L5 fx, Lt acetabular fx	
18	31	F	Tile C, LC	T12 fx, L5 fx, Lt knee fx	HO
19	30	F	Tile C, LC	Lt ankle fx, Lt tibia fx	
20	29	F	Tile C, LC	None	
21	46	M	Tile C, APC	bilateral pulmonary contusion, L2-5 fx	HO
22	26	M	Tile B, APC	None	
23	49	M	Tile C, LC	head injury, rib fx hemopneumothorax bilateral, Lt clavicular fx, L3-5 fx, retroperitoneum hematoma	rod irritation
24	46	F	Tile C, APC		
25	69	M	Tile B, LC	Lt tibia fx	
26	40	M	Tile C, VS		LFCN irritation
27	40	M	Tile C, LC		
28	22	M	Tile B, LC	Lt tibia fx	

F: Female; M: Male; C2: Cervical Vertebra 2; FX: Fracture; LT: Left; RT: Right; Col: Collateral; L3-5: Lumbar vertebra 3-5; HO: Heterotopic Ossification; LFCN: Lateral Femoral Cutaneous Nerve

may preferable under these circumstances.

Despite favorable initial clinical results, new complications, such as irritation of the lateral femoral cutaneous nerve and heterotopic ossification, have been associated with INFIX. Heterotopic ossification around the screw heads was noted in 25% to 30% of patients following screw removal. However, the most common complication was lateral femoral cutaneous neuropraxia, noted in 32% of patients [17,21,33]. In this study, there were 21.4% (6/28) cases of irritation of LFCN and 28.6% (8/28) with HO, comparable to previous studies [21,33,34]. Branches of the LFCN are located 1 cm to 3 cm lateral to the AIIS, therefore, the complication was attributed to direct damage during surgical dissection, or compression injury by a deeply recessed head of the pedicle screw or corresponding rod [28]. We suggest using polyaxial screws and we recommend that during screw insertion the surgeon should leave some space between the screw and rectus fascia. The rod should be trimmed as short as possible to reduce LFCN irritation [35].

There are several limitations to this study. First, it is retrospective; therefore cases presented may be subject to recall bias. The second limitation is that a heterogeneous group of surgeons performed the technique described by Vaidya R et al. [21]. The third limitation is the lack of a control group, with fractures treated using more traditional methods. There was no direct mode of comparison of INFIX with other techniques.

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