Original article

Effectiveness of anterior subcutaneous internal fixation (INFIX) in the management of potentially infected pelvis fractures

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ABSTRACT

Background.

Anterior plating is the treatment of choice in anterior pelvic ring fractures. In certain situations where pelvis fracture is associated with open wound, infection, abdominal injury or bladder injury - internal fixation with plate is contraindicated. Conventionally, external fixation is done in such cases. However, External Fixation is associated with pin tract infection, pin loosening, difficult wound care and less patient compliance. The present study was conducted to evaluate a possible 'middle path' between the two procedures.

Methods.

A prospective study was conducted from July 2017 to December 2019. 18 adult patients with risk of infection were treated with INFIX. The patients' data was collected on presentation, preoperatively, intra-operatively and post operatively. The patients were followed up with serial radiographs. Functional status was assessed using Iowa Pelvis Score. After radiological union, implant removal was performed. The patients were followed up for a minimum of 6 months after the removal surgery.

Results.

The average age of patients in present study was 39.55 years with a male predominance. 16 out of 18 patients were polytrauma cases with ISS more than 15.50% patients had Lateral Compression type of fracture. Radiological union was seen at an average of 3.5 months. After removal, 78% patients had excellent outcome and 22% patients had good outcome. The complications observed were LFCN irritation (27.78%) and asymptomatic heterotopic ossification (22%).

Conclusion.

Present study concludes that INFIX produces excellent outcome in pelvis fractures with risk of infection where anterior plating is contraindicated.

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1. Introduction

Fractures of the "central bone" i.e. pelvis occurs commonly when there is high energy trauma. Though it accounts for only 1.5% of all skeletal injuries,¹ the mortality rate is estimated to be around 50% when there is associated open fracture or major vessel injury.

Unstable Pelvis fractures lead to an expandable compartment,

where there can be a blood loss of up to 9–15 units of blood as there is no tamponade to stop the haemorrhage.² It is important to convert the pelvis into a 'non-expandable compartment' to stabilise the patient.³ The external fixators though clearly preferred in emergency situations, has guarded efficacy. It is cumbersome, associated with pin tract infection and loosening. It hinders wound care in patients with abdominal surgery, positioning of the patient in lithotomy position (for patients who need to undergo urethral repair surgery) and limits the mobility of the patient. Though the stability provided by plate fixation is undisputed, in certain situations where there are increased chances of infection for example open wound, infection, post laparotomy, suprapubic cystostomy done in bladder injury it is best to be avoided. Thus, there was a need for minimally invasive fixation technique which would

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Abbreviations

INFIX –	anterior subcutaneous internal fixation
ASIS	anterior superior iliac spine,
AIIS	anterior inferior iliac spine,
ISS	Injury Severity Score
IPS	Iowa Pelvis Score
VTE	venous thromboembolic event
HO	heterotopic ossification
LFCN	Lateral Femoral Cutaneous Nerve
SPC	suprapubic cystostomy
GCS	Glasgow Coma Scale
ICD	intercostal drainage tube
VAC	Vacuum Assisted Closure

decrease the mortality in patients with unstable pelvis fracture with chance of infection while being cost effective and easy to emulate.

The technique of anterior subcutaneous internal fixation (INFIX) utilises implants traditionally used in spinal fixation surgeries to stabilise the anterior pelvic ring. It was first described by M Kuttner et al.⁴ where he termed it as “pelvic subcutaneous cross over internal fixator”. The implants are placed subcutaneously, so there is no connection with the intra-abdominal surgical site, thus

decreasing the chance of bacterial contamination. As there is no extracorporeal component, the lever arm is shortened so the stability of the construct is considerably more than external fixators.³ Vaidya et al.⁵ studied the use of INFIX in 4 cases with open pelvic injuries and concluded that its low profile allows easy application of VAC over wound if necessary while stabilising the pelvis. The study aims to evaluate the radiological and functional outcome of fixation of anterior pelvis fractures with INFIX.

2. Methods

The study population constituted of patients presenting to Outdoor and Emergency with pelvic ring injury, from July 2017 to December 2018 and further followed up till December 2019. Only patients with a minimum follow up of 6 months after the removal surgery were included. The authors were the treating physicians in all the cases. Institutional ethical clearance was obtained. All the patients included were above 18 years of age with unstable anterior ring fractures, those with posterior instability were treated with additional procedure for posterior stabilisation with plate/iliosacral screws.

Patients with high risk of infection to anterior plating were included in the study i.e. open wound, abdominal/pelvic injury necessitating laparotomy/suprapubic cystostomy, Morel-Lavallée lesion (Fig. 1. A case with bilateral Morel-Lavallée lesion), obesity. The patients in the paediatric age group, associated acetabular fractures, inguinal hernia and pubic symphyseal injury were excluded from the study.

Fig. 1. A case with bilateral Morel-Lavallée lesion. 51 year old male presenting to ER with h/o RTA in shock. USG FAST was positive and patient underwent exploratory laparotomy. Intra-op mesenteric tear was found and bowel resection anastomosis was done. A-The patient also had pelvis fracture (LC type 2) with B/L Morel-Lavallée lesion (Red arrows) B-Pre operative radiograph C- Pre-operative CT scan D- Post operative radiograph.

Fig. 2. Removal of INFIX. A- Removal of blocker. B - Grasping the bent rod at one end. C - Removal of the rod through the subcutaneous plane. D - Removal of Pedicle Screw.

After initial resuscitation, patients and their family were explained the surgical plan and informed consent was taken. Patients' demographic details, mechanism of injury, Injury Severity Score, associated injuries was documented. The fracture were classified based on Young and Burgess Classification⁶. Pre-operatively, AP view, Inlet view and Outlet view X-rays and CT Scans of the pelvis was obtained. The patients underwent Pre-Anaesthetic check-up. The average time taken from admission to surgery was documented. All the surgeries were performed by/under supervision of the senior author. Intra-operatively the parameters documented were the operation time (time from incision to closure), the amount of blood loss - estimated using the Gauze Visual Analogue method and the number of fluoroscopy shots taken. The Gauze Visual Analogue method was devised by A Algadiem E et al.⁷ by using the size of the gauze and the percentage saturation to estimate blood loss.

All the patients underwent colour doppler study of bilateral lower limbs immediately post-surgery to detect any vascular

compression at 60, 90 and 120° of hip flexion. Adequate post-operative analgesia was given to all patients and thromboprophylaxis was given in high risk cases as per the opinion of the haematologist. The patients were allowed passive and assisted active hip flexion from the next day. The pain was assessed on post-operative Day 1 using the Visual Analogue Score. Depending on the associated injuries patients were allowed partial weight bearing with walker as permitted by pain as early as the second day after surgery. Stitches were removed 14 days after surgery. Serial radiographs were done to assess union and Iowa Pelvic Score was recorded at 1- and 3-months post-surgery to evaluate the functional status of the patients. Patients were advised to not bear weight without support till union. After radiological union, the removal surgery was planned and performed on an elective basis (Fig. 2: Removal of INFIX). Data was collected from the inpatient charts and hospital records. Descriptive Statistics was used to analyse results.

Fig. 3. Surgical Technique. Part A. A: patient position: supine with pillow under knee. B: Skin marking done - ASIS, Femoral artery and planned incision centered over the AIIS. C: Blunt soft tissue dissection done till bone.

Fig. 4. Surgical Technique. Part B. A. k wire placement under fluoroscopic guidance. Awl (B) and probing done before insertion of polyaxial pedicle screws (C,D). E—placement of screw. Red Asterisk (*) denoting the supraacetabular tear drop area.

2.1. Surgical Technique

Patients were operated under General/Spinal anaesthesia based on the anaesthetists' decision. Patients were placed supine on the

radiolucent operating table. Standard orthopaedics and spine instruments were needed for the surgery. A pillow was placed under the knee to keep the hip in flexion through the surgery. Foley catheter was inserted just before surgery in patients without suprapubic cystostomy. After proper painting and draping, skin markings were done to identify the anterior superior iliac spine (ASIS), Pubic symphysis, Femoral pulsations bilaterally.

2 to 3-cm incisions were given, centered over the Anterior Inferior Iliac Spine (AIIS) 3–4 cm medial and distal to the ASIS (Fig. 3. Surgical Technique. Part A). Blunt soft tissue dissection was done till the supraacetabular area was reached. First k wires were inserted in the supra-acetabular triangle commonly referred to “supra-acetabular tear drop” away from the hip joint. This was aided by intra-operative fluoroscopic guidance with the end on AIIS view i.e. obturator outlet view.³ The k wires were inserted at 20° craniocaudal angulation and 30° latero-medial angulation. After confirmation of the placement, the C-arm was adjusted to show the Iliac view and the awl was advanced directed towards the ischial spine. 2 supraacetabular iliac screws were placed, after checking the walls with sound. Polyaxial head screws were used in the present study - even though it decreases the overall strength, it provides greater adjustments for placement of the rod to decrease abdominal impingement.⁸ The polyaxial screws used were from Depuy Synthes J&J Expedium system mostly of 7 mm diameter of lengths 70 mm, 80 mm and 90 mm based on the bone stock so that 20 mm of the screw is proud from the bone (Fig. 4. Surgical Technique. Part B). According to G Osterhoff et al.⁹ the rod to bone distance of 2 cm was safest in terms of compression to superficial nerves and femoral neurovascular bundles.

The length of rod required was measured and the rods were bent in semblance with the contour of the anterior pelvis. The rod was inserted from one side and guided gently in the subcutaneous plane towards the other side. Once the rod was near the

Fig. 5. Surgical Technique. Part C. A: Insertion of a contoured rod in the subcutaneous plane while applying pressure on the abdominal wall anteriorly while guiding it towards the contralateral AIIS. B: The advancing end of the rod is placed onto the head of the screw. C: Reduction done with the help of distractor. D: Placement of blocker on the screw. E: Cutting the extra rod leaving 1 cm from the screw.

Table 1

Young and Burgess Classification of pelvic ring fractures in our study.

Type of fracture	Number (percentage)
Lateral compression (LC)	9 (50)
-LC type 1	2 (11.11)
-LC type 2	5 (27.78)
-LC type 3	2 (11.11)
Anterior -Posterior compression (APC)	3 (16.67)
-APC type 2	
Vertical Shear (VS)	4 (22.22)
Combined Mechanism	2 (11.11)

contralateral screw, it was guided onto the opposite pedicle screw using rod-holding forceps/Allis forceps. The blocker was locked onto the pedicle screw head on one side once the rod was in position. Reduction is done by distraction/lateral compression of the pelvic ring/traction and internal rotation. In cases with LC type fracture, reduction was mostly achieved with distraction using spinal distraction instrument. In cases with VS fracture, reduction required longitudinal traction and further manipulation. In open book type of fracture, the pelvis was internally rotated by internally rotating both the lower limbs and strapping them together above the ankle. Final tightening was done after confirming satisfactory reduction (Fig. 5. Surgical Technique. Part C). The position of the rod was checked by inserting two fingers between the rod and bone. 1 cm of the rod was kept proud on each side to help in removal.

3. Results

During the study period 51 cases of pelvis fracture presented to the study centre, out of which 18 patients were included in the study group. The average age of the patients included was 39.55 years (standard deviation 6.99, range – 24–52 years). 15 (~83%) patients were male and 3 (~17%) patients were female. Most frequently encountered mechanism of injury was Road Traffic Accident (14 out of 18) involving heavy goods vehicle and motorcycles. 4 out of 18 of patients presented with a history of fall from height. The patients included had higher risk of infection i.e. patients post laparotomy (4 patients), patients with bladder injury (5 patients), patients with Morelle Levalle lesion (3 patients – 1 patient also had to undergo laparotomy for mesenteric tear), patients

with multiple abrasions (3 patients) and type 1 wounds (2 patients) after debridement, and 2 patients with BMI>30 kg/m². The pelvis fractures have been classified based on Young and Burgess Classification (Table 1) and the associated injuries in polytrauma patients have been summarized in Table 2. Two patients with LC fracture type 1 was also included. One patient had undergone emergency laparotomy and was found to have recto-sigmoid perforation. He underwent the procedure to stabilise the pelvis so that early mobilisation could be given. The other patient had associated urethral injury and the surgery was performed so that he could be placed in lithotomy position to aid the urologist.

Most patients (12 out of 18) presented to the emergency within 24 h from injury. However, there was a delay in the presentation of the other patients who were referred from other centres after initial resuscitation.

On presentation Injury Severity Score was calculated for all patients. The range of the score in the current study was from 14 to 40, the average score being 27.61 (Standard Deviation of 7.3576). The patients were put up for surgery on an average of 7.44 days (Standard deviation 2.43) after admission. In 4 patients who underwent emergency laparotomy/craniotomy, surgery had to be delayed more than 10 days. Intra-operative parameters are tabulated in Table 3. In 7 patients an additional procedure was done for fixation of posterior instability at the same sitting after completion of the procedure (5 patients were treated with percutaneous screw fixation and the other 2 required plating).

On Post-Op day 1, the surgical site pain was evaluated using Visual Analogue Score for pain – which was an average of 3.94 (with Standard Deviation 0.63). Radiologically the patients were followed up with monthly X-rays to assess union. The union time ranged from 2 to 5 months. The average time for union was 3.5 months (Standard Deviation was 0.78). Once union occurred, the removal surgery was planned. The average time between the two surgeries was 5.94 months (standard deviation 0.99). In one patient there was an exceptional delay of 9 months as he was admitted under the Department of Urology for Suprapubic Cystostomy reversal. The average follow up period of patients was 12.78 months (standard deviation 1.17).

The patients in the present study tolerated the implant well, one patient experienced discomfort while sitting and bending forward. The functional status of the patients were evaluated using Iowa

Table 2

Associated injuries in polytrauma patients in the study.

Associated Injury	Number (percentage)
Abdominal organ injury – necessitating laparotomy	4 (22)
Bladder injury (requiring SPC)	5 (28)
Head injury (GCS <13)	3 (16)
Thoracic trauma (Haemothorax and Pneumothorax drainage via ICD)	4 (22)
Additional Lower extremity long bone fracture	3 (16)

Table 3

Intra-operative parameters.

Parameter under assessment	Subdivisions	Frequency of the subdivision	Range	Mean	Standard deviation
Operation time (min)	50–70	5	55–99	80.00	13.86
	71–90	9			
	≥ 90	4			
Blood loss (ml)	<100	10	60–120	86.67	16.80
	≥100	8			
Fluoroscopy shots (number)	<55	2	47–84	68.67	9.46
	55–75	13			
	≥75	5			
Hospital stay (in days)	<25	8	17–38	25.22	5.39
	≥25	10			

Table 4
Iowa Pelvic Score of the study.

Time when measured	Grade ^a				Range	Mean (Grade)	Standard Deviation
	Poor <55	Fair 55–69	Good 70–84	Excellent 85–100			
After 1 month	—	14	4	—	58–74	64.89 (Fair)	4.35
After 3 months	—	1	13	4	69–88	79.89 (Good)	4.52
After removal	—	—	4	14	80–91	85.61 (Excellent)	3.01

^a Grade as depicted by Nepola et al-(10).

Pelvic Score at 1 month and 3 months post implantation and after removal and graded as excellent (100–85), good (84–70), fair (69–55) and poor (less than 14). The results are tabulated in Table 4. The score improved by 23.11% from 1 month to 3 months post-op and by 31.9% at the time of removal of the implant.

During the follow up, vigilant survey was done for detection of complication. LFCN irritation was observed in 5 patients. The reported complaints of numbness and mild paraesthesia resolving within 6 months after removal surgery with conservative management. 4 patients (~22%) had asymptomatic heterotopic

ossification. There was no Surgical Site Infection, implant failure, thromboembolic episode, femoral nerve injury observed. One patient observed some discomfort during extremes of hip flexion while stooping forward in sitting position, however it did not necessitate early removal of the implant before union. In all the cases the implant was removed after union, there were no cases of delayed union or non-union.

Fig. 6 and Fig. 7. Pre operative radiograph, Post operative radiograph and functional status.

Fig. 6. Pre operative, Post operative radiograph and functional status. 35 year old male presented to Emergency post RTA with LC type 1 #, pneumothorax and bladder injury. A- Pre operative radiograph. B-Pre operative 3D CT Scan. C-Post operative radiograph on post op day 2. D-Radiograph showing union at 4 months. E–functional status at 3 months, patient was able to squat and sit cross legged without difficulty. F- radiograph after removal surgery.

Fig. 7. Pre operative, Post operative radiograph. 53 year old male presented to Emergency post RTA with LC type 2 # A- Pre operative radiograph. B-Pre operative CT Scan. C-Post operative radiograph D - Radiograph after removal surgery.

4. Discussion

The average age (39.55 years with most patients being less than 50 years) and sex (male 83%) of patients in present study was similar to the publication by S Ghosh et al.¹¹ He reported the average patient age in his study to be 37.27 years with male preponderance. He concluded that driving under influence was more common among males and it could be a probable cause for this result. 4 (out of 18) had a history of fall from height in whom Vertical shear type of fracture was more common, otherwise 50% patients had lateral compression type fracture. The mean hospital stay in current study (25.22 days) exceeded that reported by S Ghosh, which was 14.4 days.

In this study, we employed ISS score to assess the trauma severity as it takes into account each injured region. Major trauma [defined as ISS more than 15¹²] was found in 88.89% (16 of 18) of the cases. Yingchao et al.¹³ studied intra and postoperative parameters in 39 patients treated with plate and INFIX each. In his study average operation time was 70.3 min and mean intraoperative blood loss was 97.1 ml, which is comparable to the results in the current study and considerably less than what he reported for plate fixation.

We performed bilateral lower limb colour doppler in all patients after surgery on the same day to make sure there was no compression of the femoral vessels. The first case of vascular occlusion was published by A Smith et al.¹⁴ where there was immediate loss of pulsation and mottling of left leg. He thus recommended all surgeons to perform routine doppler to confirm triphasic arterial response and to keep the foot free from the surgical drape.

Pelvis injury patients are prone for venous thromboembolism (VTE). In the study conducted by R Steer¹⁵ only 17% patients (considerably lower than the 61% reported in other studies) suffered from VTE. He administered prophylactic low molecular weight heparin to all patients for 12 weeks. In the current study, 40 IU of enoxaparin was administered daily to patients with high risk. This included the patients in whom long term immobilisation was anticipated for example the patients who had undergone laparotomy/craniotomy/ICD insertion/with associated lower limb fracture/open wound, patients with prior history of VTE/AMI, patients on

OCP/HRT and patients with BMI >29. The INR was monitored and the therapy was continued till discharge or till the patients ambulated independently after converting to oral anticoagulant therapy as advised by Haematologist. 14 out of 18 patients were administered thromboprophylaxis. Among the other patients – 3 had multiple abrasions and one had type 2 GA wound which healed with primary intetion, in them prolonged immobilisation was not anticipated.

The Iowa Pelvic Score¹⁰ was implemented to assess the post-operative functional status. It is questionnaire based and the patients are required to answer 20 questions on activities of daily living. There are individual scores given to work status, pain, visual pain line, limp and cosmesis. It includes patients social and vocational status.

R Vaidya et al.¹⁶ in his study addressed 83 pelvic fractures with infix and followed up to 35 months. He deemed the fracture to be healed when the patient was allowed to bear weight which was by 12 weeks in all except those with spinal injury. The average time between the two surgeries was 5.3 months in his study (5.94 months in the current study). R Vaidya reported heterotopic ossification in 69.5% patients, about half of them were severe. He suggested that in patients with high risk for heterotopic ossification oral Indomethacin 25 mg thrice a day can be administered for 5–6 weeks. NSAIDs inhibit the production of prostaglandins (Prostaglandin-E₂ has been proposed to be among the systemic factors responsible). In our cohort, 22% patients had asymptomatic HO i.e. 4 out of 18. None necessitating excision. 1 out of these patients were associated with head injury. Obesity and morel lavallee lesion predisposes patients to infection, however with INFIX the risk was lesser than that of plating. In the above mentioned study persistent LFCN irritation of varying degree was reported in 25% of patients, all of which resolved after removal.

There are few notable limitations in the current study. The study group consisted of 18 patients who were followed up for 11–15 months, limiting the validity of the results. There was no control in the study. Due to technical limitations, there was no provision to quantify the fluoroscopic radiation intra-operatively. Further studies are required to evaluate the outcome of the newer variations of implementing INFIX for example Unilateral INFIX, Extended unilateral INFIX, Extended Bilateral INFIX¹⁷ which have shown good biomechanical stability in in-vitro studies.

5. Conclusion

INFIX can be used in patients to stabilise anterior pelvic ring fractures through a minimally invasive approach. It is easily reproducible with a short learning curve. Very few complications are associated with the procedure and serious complications can be avoided with due vigilance. It appears to be a plausible alternative to external fixation in potentially infected pelvis fractures.

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Declaration of competing interest

The authors declare no conflict of interest.

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