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Pelvic Ring Fractures INFIX: Minimal Invasive Technique

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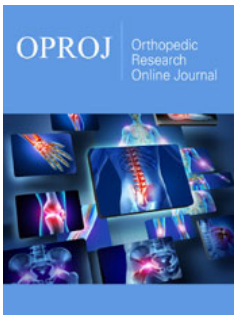

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Abstract

Fracture pelvis is a serious injury with significant morbidity. There are many surgical options for treating unstable anterior pelvic ring fractures, but the anterior subcutaneous internal pelvic fixator (INFIX) showed high union rate with low complications rate. We describe our technique and instruments in applying INFIX which make it faster, feasible with smaller incision. We had used in more than 100 patients without any loss of reduction after it.

Keywords: Pelvis; INFIX; AIIS; Obturator inlet; Obturator outlet; Iliac oblique; Polyaxial; Pedicle; Screw

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Introduction

Pelvic fractures, though accounting for 2-8% of all fracture cases, wield significant influence over patient outcomes, posing substantial morbidity and mortality risks [1,2]. Unstable pelvic fractures manifest in anterior, posterior, or combined configurations, prompting a diverse array of management strategies such as external fixation (Exfix), symphyseal plating, intramedullary ramus screws, and the anterior subcutaneous internal pelvic fixator (INFIX) [3].

External fixation (Exfix), while a viable option, carries a notable complication burden, with reported rates ranging from 7% to 50%. These complications include pin-tract infections (afflicting 25%-50% of patients), osteomyelitis, hardware loosening (occurring in 10% of cases), and the potential for loss of reduction (up to 33%). Exfix also presents practical challenges in obese patients and may impede mobility [4,5]. Alternatively, open reduction and internal fixation, while effective, come with drawbacks such as increased blood loss, extended operative durations, surgical site morbidity [6], and fixation failure rates ranging from 12% to 75% [3].

The pioneering work of Kuttner et al. [7] in 2009 introduced the anterior subcutaneous internal pelvic fixator (INFIX) [7], a groundbreaking technique subsequently referred to as "INFIX" in English literature in 2012 [8]. INFIX involves a subcutaneous cross-over internal fixator approach for stabilizing anterior pelvic ring fractures. This method employs polyaxial pedicle screws anchored to the supra-acetabular region of the ileum on both sides, interconnected by a contoured rod inserted subcutaneously following successful closed reduction [9]. Biomechanically, INFIX outperforms Exfix in terms of stiffness and stability, although it falls slightly short of the rigidity provided by anterior plate fixation [10].

A plethora of research reports investigating INFIX outcomes consistently reveal high union rates and relatively low complication profiles. Predominant complications involve lateral cutaneous nerve irritation or palsy (experienced by 5%-25% of patients, typically resolved after implant removal), heterotrophic ossification (affecting 32% but often asymptomatic), and surgical site infections (occurring in 3% of cases) [6,11,12]. In sum, INFIX emerges as a safe and effective minimally invasive technique for addressing complex anterior pelvic

ring fractures, delivering exceptional fracture reduction, robust radiological and functional outcomes, and reliable fracture healing [11].

Our technique

Indication: Various classification systems exist for pelvic fractures; however, we endorse the Young and Burgess Classification [13] due to its widespread utilization in contemporary practice and its foundation on injury mechanisms [14]. This classification encompasses four types: Lateral Compression (LC) (I to III), Anteroposterior Compression (APC) (I to III), Vertical Shear (VS), and Combined Mechanism (CM). Among these, LC injuries represent the most prevalent pattern.

While the indications for INFIX application remain somewhat undefined, the prevailing consensus among experts is to reserve this technique for addressing unstable pelvic injuries, as categorized by the Young and Burgess Classification. These typically include cases falling under Vertical Shear, APC 2, APC 3, LC2, and LC3 classifications.

We know that posterior sacroiliac complex is more important to pelvic ring stability but still anterior ring responsible for about 40% of the stiffness of the pelvis [15]. In our view any fracture involving the pelvic ring in more than one point is unstable and should be stabilized. If the case had both posterior and anterior injury, we start by posterior stabilization (mostly by sacroiliac screw) and then address anterior part. Usually, we keep infix for at least 3 months before removal.

Our primary aim was to streamline the INFIX procedure to reduce surgical time, blood loss, and radiation exposure. To achieve this goal, our senior author introduced a novel tool, the MIS ASIPF (manufactured by Nuvasive USA). This innovative instrument played a pivotal role in our approach. Instruments and implants are shown in Figure 1.

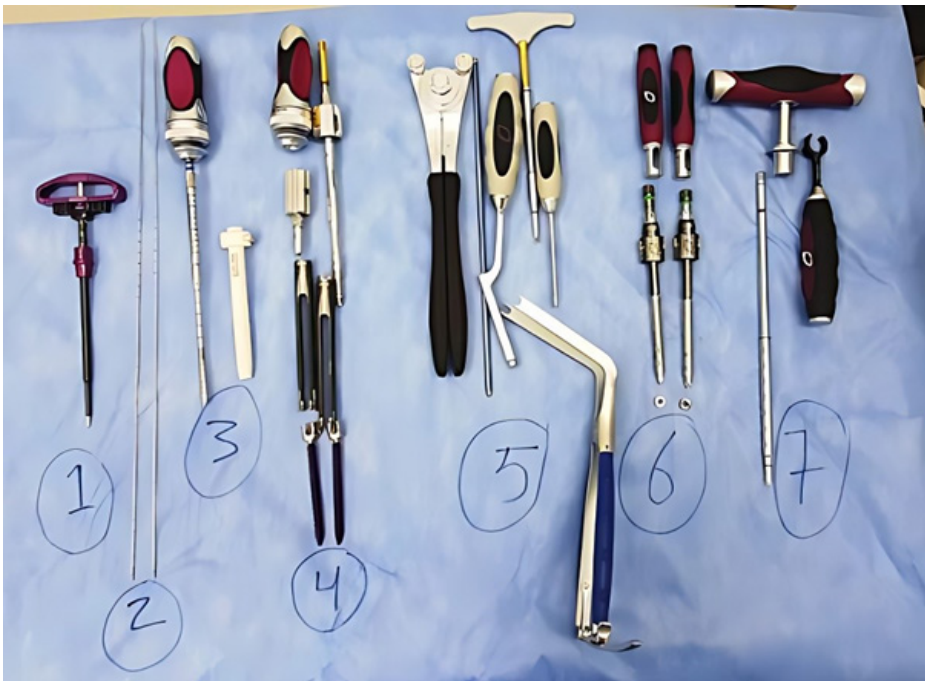

Figure 1: Instruments.

1. PAK needle
2. Guide Wires
3. Taping (Tape 6.5mm with its soft tissue sleeve) the Cortical Bone through the soft tissue protection Sleeve
4. Screws (7.5- 8.5mm diameter, length 70-80mm, With The extenders
5. Rod (5.5mm diameter, length 220-280mm, with holder, and bender for contouring the rod)
6. Sets screws (2 in, one for each side, with the inserter and the reducers)
7. Final tightening tools

For the INFIX procedure, we employed cannulated polyaxial pedicle screws with diameters ranging from 7.5 to 8.5mm, connected by a variable-length rod of 5.5mm, tailored to measurements ranging from 220 to 280mm. Our equipment also included a wide-gantry C-arm and pulse oximeters connected to both feet to monitor circulation, a crucial aspect to prevent vascular occlusion, as previously reported [16].

The patient was positioned in a supine manner on a Jackson's or radiolucent table. Sterile draping was applied, encompassing the area from above the umbilicus to the proximal thigh, ensuring that private areas were covered with sterile towels (Figure 2). A crucial anatomical reference for the INFIX procedure is the supraacetabular corridor, a region of dense bone extending from the anterior Inferior Iliac Spine (AIIS) to the Posterior Superior Iliac Spine (PSIS). This corridor presents as a teardrop shape on the obturator outlet view [17,18].

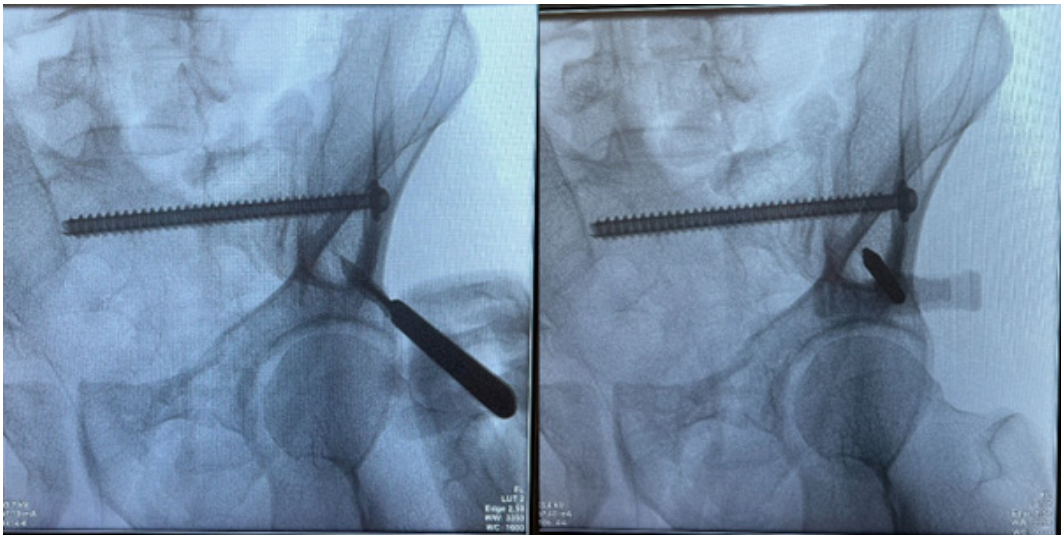

Figure 2: Starting point on obturator outlet view.

Our surgical approach began with a 1-1.5cm longitudinal incision cantered over the AIIS, cutting only skin and subcutaneous tissue, and using small snap in blunt discussion of the deep fascia and muscles, we exercised caution during dissection to avoid injury to the Lateral Femoral Cutaneous Nerve (LFCN). The starting point, situated at the centre of the teardrop on the obturator outlet view, should be at least 2cm superior to the acetabular dome to prevent capsular penetration directed just above the sciatic notch, a critical consideration verified in the iliac oblique view directed toward the PSIS between the inner and outer tables of the ilium, confirmed in the obturator inlet view (Figure 2).

The procedure continued with the insertion of the PAK needle, hammered gently until its shoulder was properly positioned (Figure 3). This step was closely monitored under the C-arm in the three views previously mentioned. Subsequently, a guidewire was passed over the needle under C-arm guidance for approximately 100mm, directed just above the sciatic notch (Figure 4). To ensure precision, we employed a 6.5mm tap before inserting a 7.5- or 8.5-mm diameter screw, (The Tape has a soft tissue protector protects the tissue during taping), with lengths ranging from 70 to 80mm, tailored to the patient's anatomy (Figure 5).

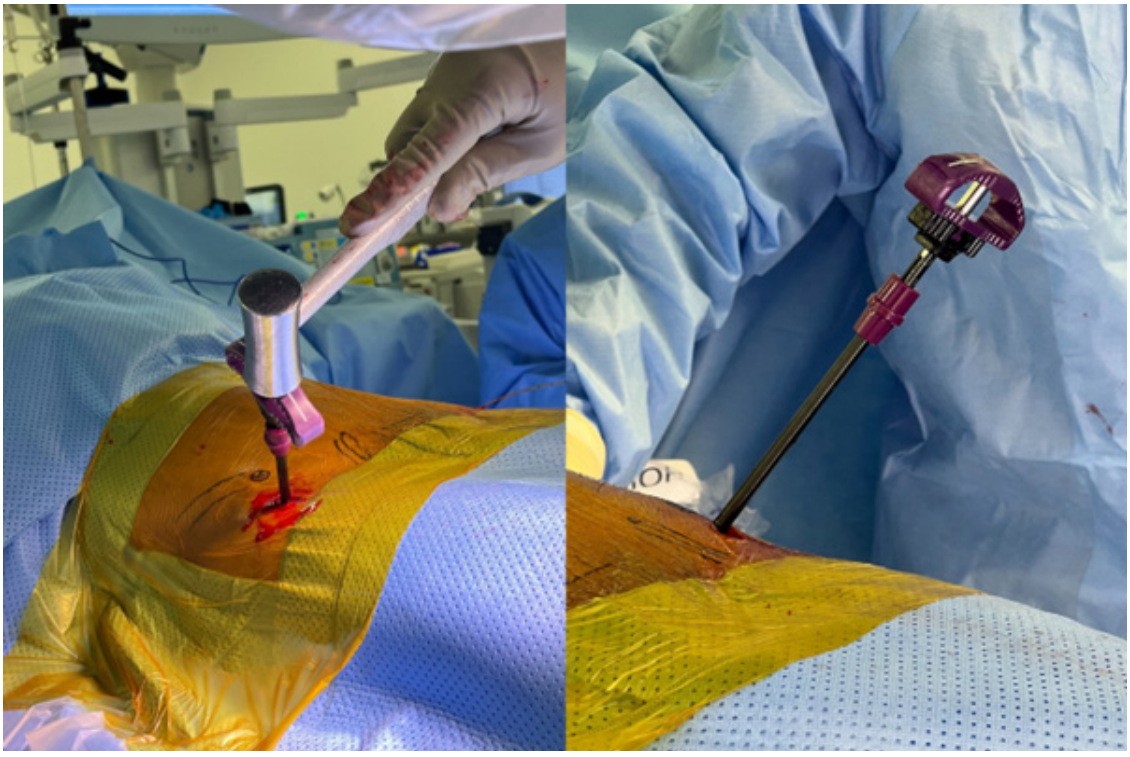

Figure 3: Insertion of PAK needle.

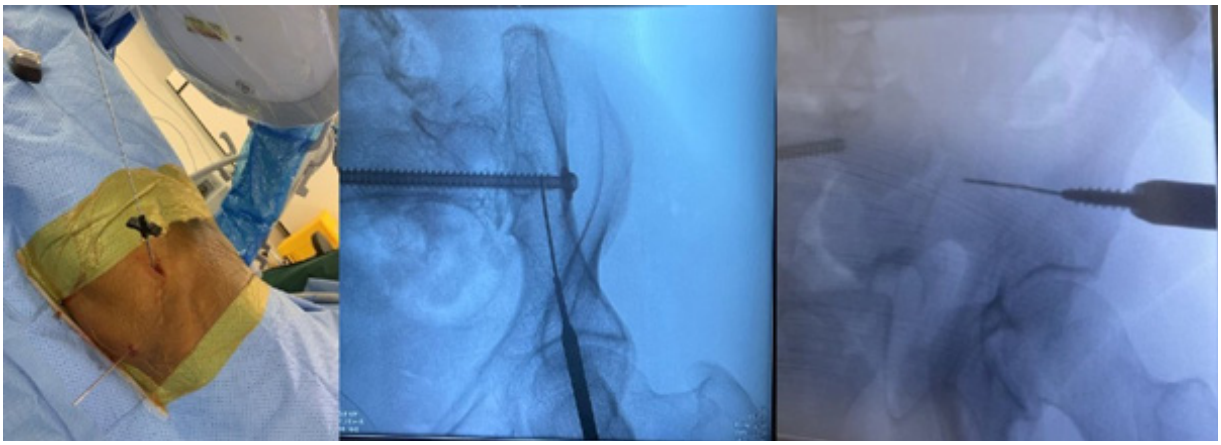

Figure 4: Passing guide wire on obturator inlet view & iliac oblique views.

Figure 5: Tapping & screw fixing.

We are inserting the screws to a distance enough not to be prominent under the skin, and at the same time to be on reasonable distance form bone it would be usually between 1.5 to 2cm from bone, we are depending on the pulse oximeters on both feet to avoid any compression over the femoral arteries.

The same steps were replicated on the opposite side, effectively securing both screws in place. The connecting rod, with a diameter of 5.5mm, was meticulously prepared for insertion. It was securely held by the handle holder, ensuring a firm grip. Subsequently, a bender was employed to shape the rod into a smooth curve, with blunt ends designed to facilitate gentle insertion (Figure 6).

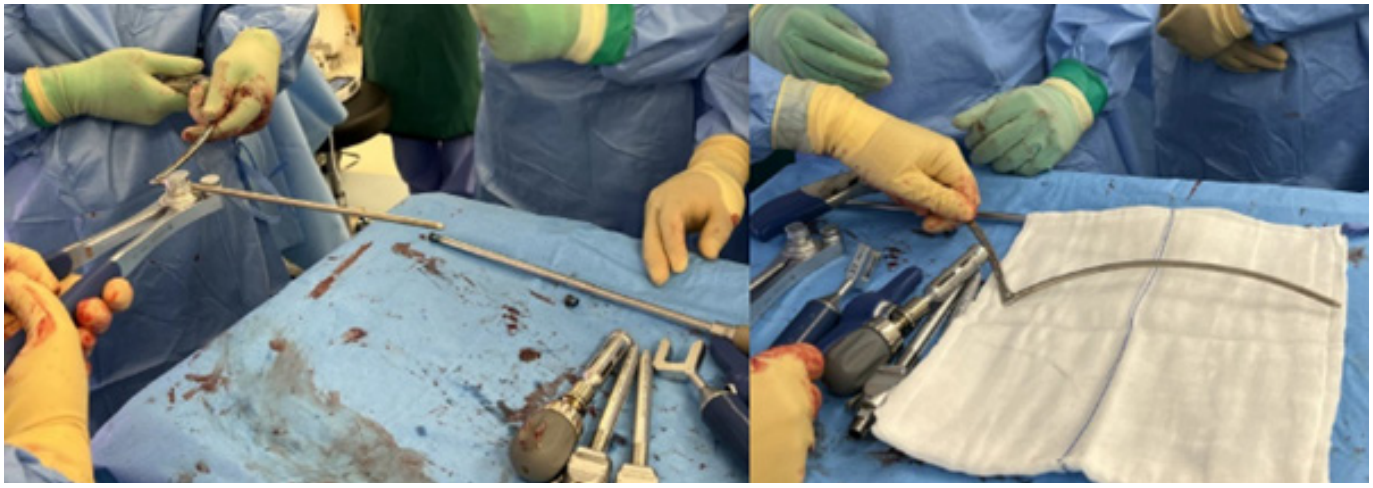

Figure 6: Rod contour, final shape.

When inserting the rod, a methodical approach was taken. It was passed through the extender from one side, ensuring that it remained palpable beneath the skin throughout its advancement until reaching the other extender. During this step, deliberate manipulation was applied to achieve maximal fracture reduction prior to the application of set screws. The rod was inserted with its curve thoughtfully aligned with the natural groin crease, situated between the abdominal fold and the flat region connecting the two screws.

As a precautionary measure, we conducted length measurements of the rod before both contouring and insertion. We highly recommend leaving a slight protrusion, typically in the range of 0.5 to 1cm, extending from the screw head. This practice serves the dual purpose of averting the risk of inadequate length that could lead to failure or excessive length that may provoke tissue irritation. If necessary, any excess length was trimmed after achieving the final rod position and securing it in place.

It is worth noting that adhering to a minimum distance of 2cm between the rod and the bone was recommended to mitigate the risk of neurovascular compression [19]. We also introduced a safety measure by monitoring pulse using bilateral pulse oximeters, which provided valuable real-time feedback. In our experience, we found that employing pulse oximeters as monitoring tools was particularly advantageous, offering a superior means of assessment compared to relying solely on distance measurements (Figure 7).

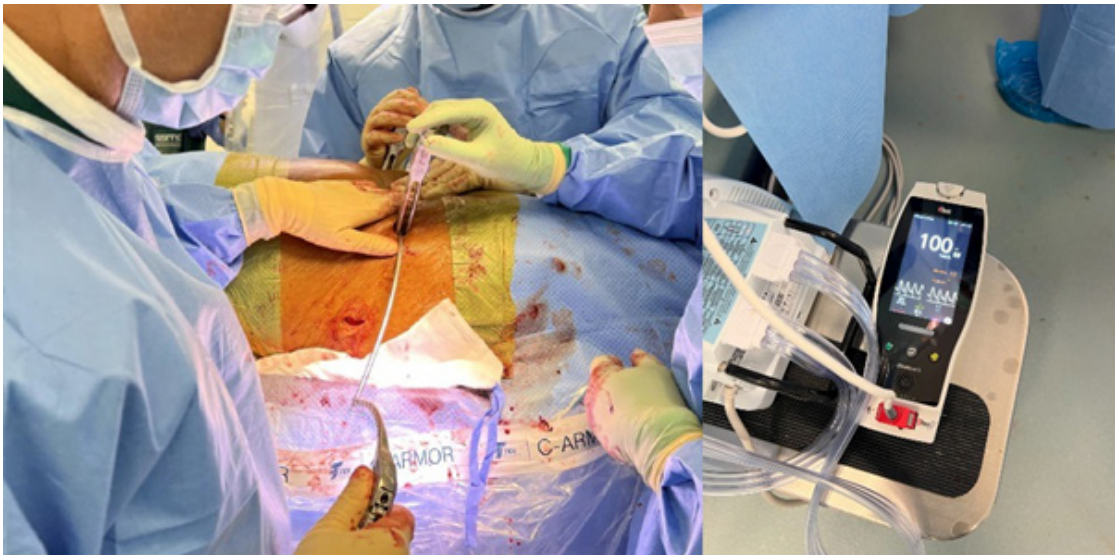

Figure 7: Rod insertion, monitoring pulse using pulse oximeters.

To ensure optimal reduction, we assessed it under imaging and made any necessary compression or distraction adjustments before securing the rod in place (Figures 8, 9). The final steps of the procedure included a thorough examination of the reduction under imaging, a stability check, assessment of both feet for pulse and oxygen saturation using pulse oximeters, and meticulous surgical site washing. Closure was accomplished with subcuticular Monocryl sutures.

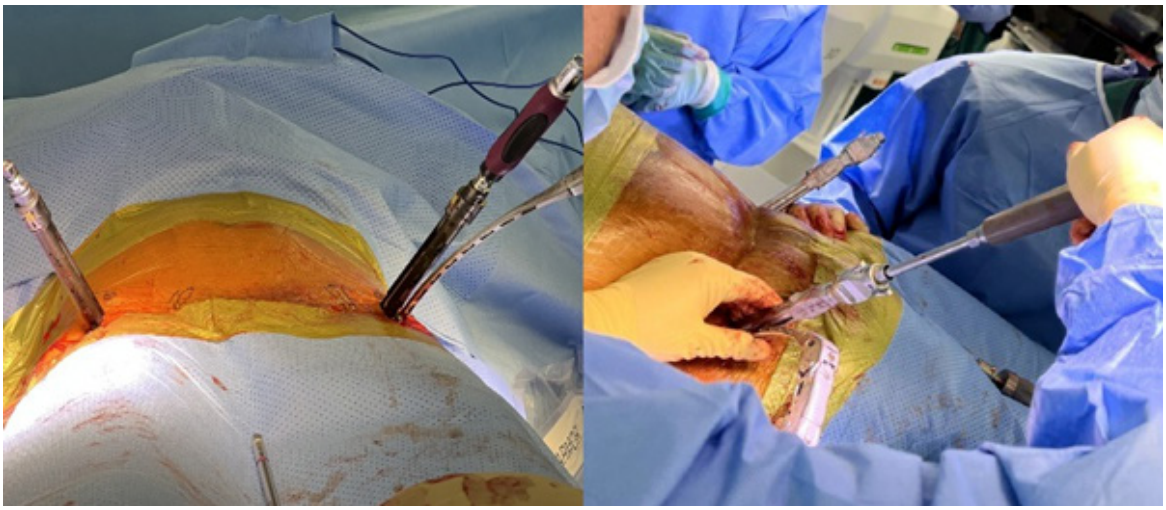

Figure 8: Final reduction, final fixation with sets screws.

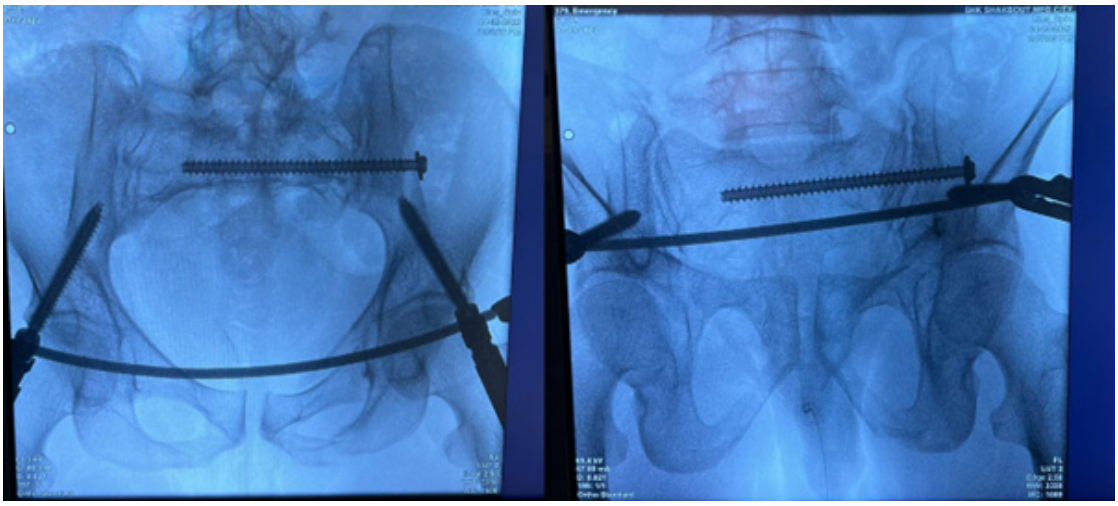

Figure 9: Final X ray outlet & inlet pelvic views.

Our postoperative protocol included: Venous thromboembolism (VTE) prophylaxis for five weeks.

Mobilization in a wheelchair for six weeks, followed by weight-bearing using a walker as tolerated, contingent on the patient's general condition and the presence of other injuries. Evaluation of healing at six and twelve weeks. Removal of the INFIX apparatus, typically after 12-14 weeks. For cases of diastasis, the apparatus was left in place for an extended period, usually a minimum of 16 weeks. Adequate analgesia as needed. Special consideration for patients experiencing neuralgic pain, who may require additional medication.

Discussion

The pelvic INFIX technique has emerged as a secure and consistently reproducible approach for addressing unstable anterior pelvic ring injuries. One of its distinct advantages lies in its ability to facilitate smaller incisions, resulting in reduced blood loss and a diminished burden of comorbidities.

In a comprehensive study conducted by Wang et al. [20], a comparative analysis was performed between INFIX and open reduction and internal fixation for Type B (Tile classification) pelvic fractures. The findings notably favoured the INFIX technique, demonstrating superior outcomes in terms of operation time, length of hospital stay, and clinical as well as radiological assessments during the six-month follow-up period. It's worth noting that, in this study, subjective questionnaires were not administered to the patients.

The documented complications associated with the INFIX technique are well-delineated. Among these, Heterotopic Ossification (HO) is the most prevalent, occurring in 36% of cases [21]; however, it's important to emphasize that all instances of HO remained asymptomatic. Additionally, Lateral Femoral Cutaneous Nerve (LFCN) injuries were reported in (26.3%) 21 of cases, with the majority experiencing recovery after the removal of pins. The infection rate remains relatively low at 3%. These cases are effectively addressed through procedures such as irrigation and debridement, administration of antibiotics tailored to the specific pathogen cultured, and potential removal of affected materials. It is crucial, however, to consider removal no sooner than four weeks postoperatively to ensure the highest level of patient safety [22]. INFIX for the anterior pelvic ring is a safe and reliable procedure [21,23]. Healing following INFIX application was observed in 99.6% of cases [21].

Our refined technique has demonstrated several key advantages, including expeditious application, shorter surgical duration, reduced blood loss, and minimized radiation exposure. Furthermore, it exhibits a simplified learning curve, rendering it more accessible and reproducible for clinicians.

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