

Pelvic Ring Stabilization Using Anterior Subcutaneous Internal Fixation in Bladder Exstrophy Repair

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Abstract: Bladder exstrophy (BE) is a congenital condition involving malformation of the anterior abdominal wall leading to an extruded bladder and with an “open” bony pelvis deformity and symphysis pubis diastasis. Multiple surgical techniques have been described for correction of the bony pelvis deformity in classic bladder exstrophy. A common way to close the pelvis and assist with bladder closure uses bilateral double iliac osteotomies stabilized with external fixation. However, external fixators are cumbersome, unsightly, and have an increased risk for pin tract infection due to contaminants such as urine and feces. We describe an alternative to external fixation with the use of subcutaneous anterior pelvic internal fixator (INFIX), which typically is reserved for adult pelvic trauma and is an effective alternative for anterior pelvic ring stabilization in older bladder exstrophy patients.

Key Concepts:

- External fixators in bladder exstrophy patients are cumbersome, unsightly, have an increased risk for pin tract infection, and are costly due to the complexity of the constructs to maintain the reduction.
- INFIX is a novel fixation technique that is well tolerated and an effective alternative for anterior pelvic ring fixation and stabilization in older bladder exstrophy patients.
- The methods also allow patients to sit upright, turnover from side to side, and lie in the prone position.

Introduction

Bladder exstrophy (BE) is a congenital condition involving malformation of the anterior abdominal wall leading to extruded bladder and other genitourinary and musculoskeletal system abnormalities.¹ The prevalence for BE is approximately 1 in 50,000 births, and males have a two-fold increased rate in comparison to females.^{2,3} Orthopaedically, these patients are known to have a large diastasis in the pubis measuring a mean of

4.2 cm at birth and progressing to 14.2 cm in adulthood. This “open” bony pelvis results in a deformed and poorly functional pelvic floor that fails to provide proper support for the bladder and urethra.^{1,4}

Pubic symphysis approximation is essential for successful repair. There are a variety of ways to do this depending on the age of the patient and the degree of

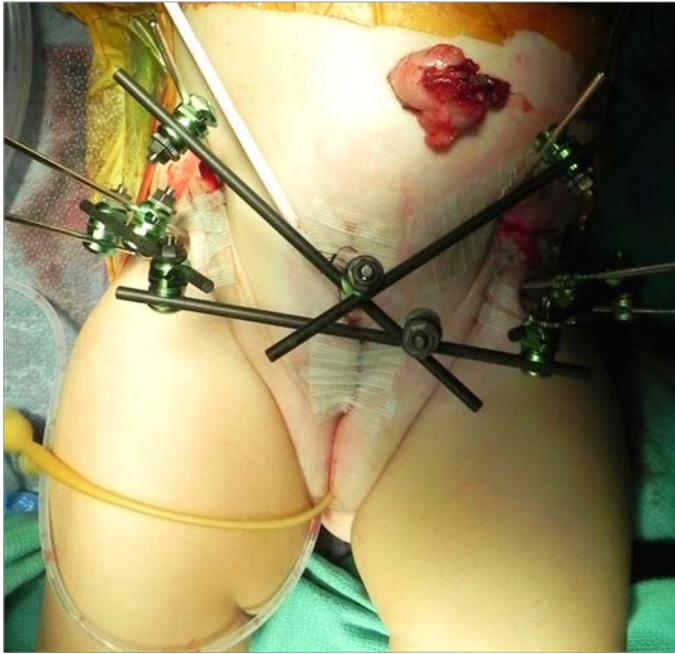


Figure 1. Anterior pelvic fixator in case of cloacal exstrophy. Figure from SJ Schoenleber, IPOS Resident Case Presentation, 2013

diastasis. Some form of bilateral pelvic osteotomy is usually required except in newborns or in patients with a small diastasis. Osteotomies are required to close the symphysis to prevent and treat pelvic organ prolapse in older females. Multiple surgical techniques have been described for the correction of the pelvic deformities, including that described by Sponseller et al.⁵ This technique involves bilateral vertical unicortical iliac wedge osteotomies and rotation of the iliac wings together to close the pelvic volume. Bilateral Salter osteotomies are also performed which facilitates symphysis pubis closure. The authors use external fixation to stabilize the osteotomies.⁶

The advantage of external fixation is the ability to gain fixation of the different bone fragments and to use the pins to manipulate and close the defects. However, external fixation does provide some challenges with pin site inflammation/infection, tends to obstruct access to the anterior abdominal wound, and can be challenging when a colostomy is part of the treatment for cloacal exstrophy (Figure 1). In addition, long term external



Figure 2. Preoperative anteroposterior (AP) pelvis radiograph demonstrating “open book” anatomy

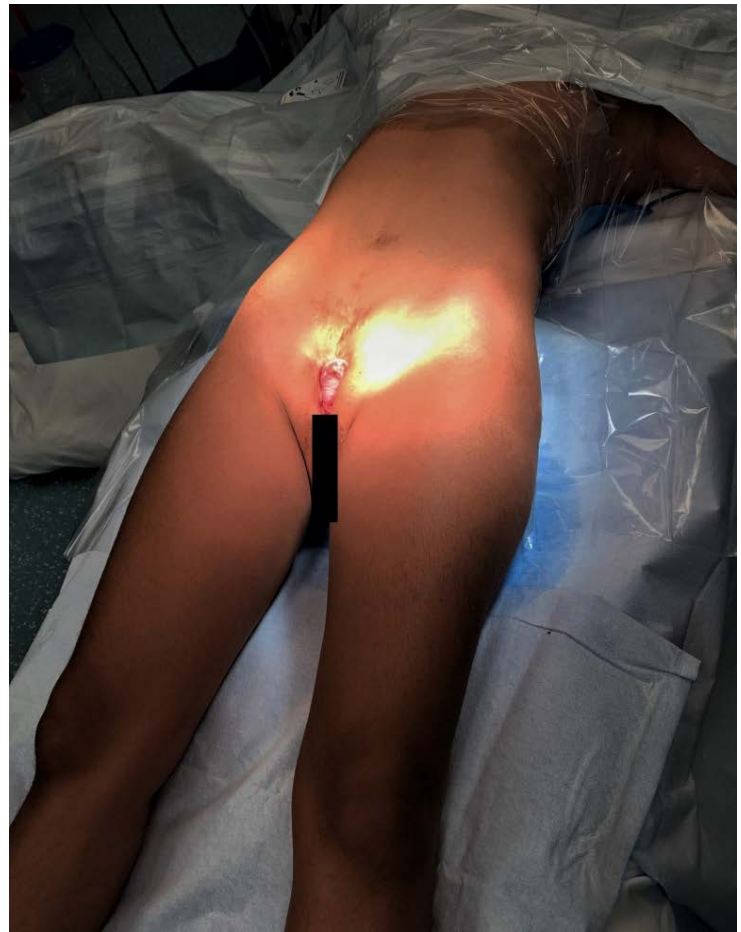


Figure 3. Preoperative prepping and positioning of the patient

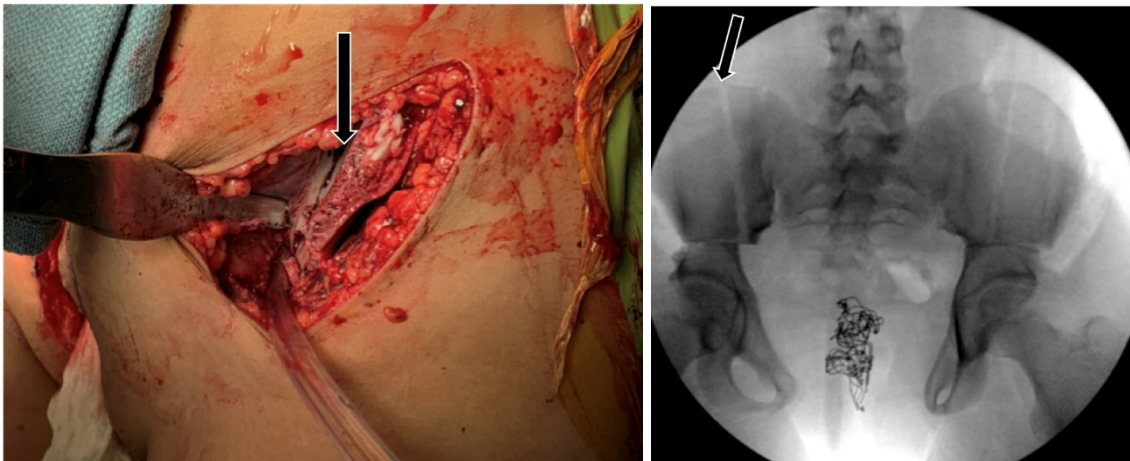
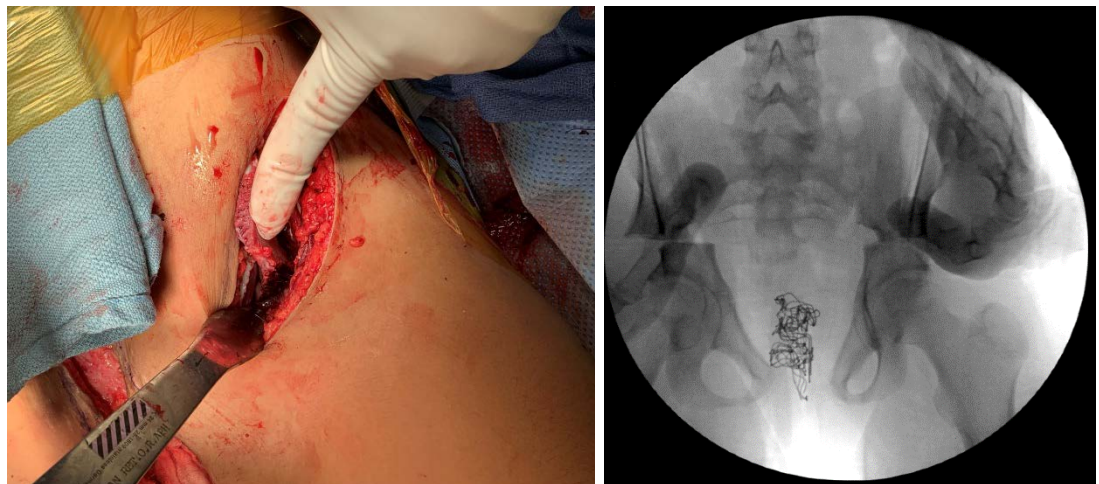


Figure 4. Clinical (A) and radiographical (B) demonstrations of vertical unicortical posterior osteotomies of the iliac wings (black arrows)

Figure 5. Clinical (A) and radiographical (B) demonstrations of lateral compression of the iliac crests and with displacement of the distal fragment; the symphysis can now be approximated



fixation is not well tolerated and any potential benefits from longer term fixation is not possible.

We describe a 12-year-old female with a bladder exstrophy repair by cystectomy and ureterosigmoidostomy without prior osteotomies that presented with complete vaginal-uterine prolapse (Figure 2). The patient was treated using Sponseller’s osteotomy technique for bony correction. However, instead of using external fixation, we maintained symphysis closure with the use of an anterior internal fixator previously described in the adult pelvic trauma literature.⁷ The anterior internal fixation system (INFIX) utilizes a subcutaneous rod (superficial to the fascia) attached to bilateral supra-acetabular iliac screws to successfully close and fix the anterior pelvic diastasis after all the osteotomies have been performed. To the best of our

knowledge, the use of this device for anterior pelvic fixation has not been described in the setting of bladder exstrophy correction. The purpose of our project was to describe the procedure, the insertion technique, and demonstrate the outcome with this modified technique.

Surgical Technique

The following procedure is based on Sponseller et al. described technique with modifications below.^{5,6}

Positioning and Prep

Under general endotracheal anesthesia, the patient was positioned supine on a regular radiolucent table with the entire torso laying over folded blankets to raise the whole pelvis. This helps with the surgical approach, which tends to be more posterior because of the retroverted pelvis. The patient was then scrubbed and

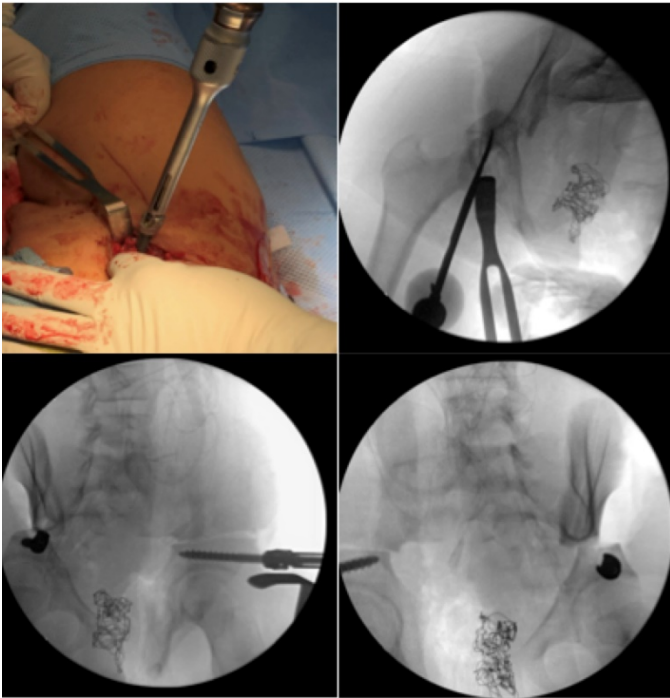
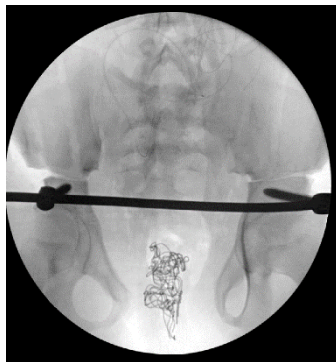


Figure 6. Clinical (A) and radiographical (B, C, D) demonstrations of access point at the AIIS area and placement of the multi-axial pedicle screw

Figure 7. Subcutaneous rod placement connecting both supra-acetabular screws



draped from the xiphoid down to the proximal femurs (Figure 3).

Surgical Exposure

We performed bilateral oblique “bikini” skin incisions in layers down to the fascia using a Smith-Petersen interval. We exposed the outer and inner iliac tables to the sciatic notch. The posterior inner wall was then exposed to the sacroiliac joint.

Osteotomy

We performed a vertical unicortical osteotomy about 1 to 1.5 cm lateral from the sacroiliac joint in a wedge fashion, leaving the posterior cortex intact on both sides of the pelvis (Figure 4A and 4B). We then performed bilateral Salter type osteotomies using a Gigli saw in the supra-acetabular region between the anterior-superior and anterior-inferior iliac spines (ASIS/AIIS).

Reduction of Deformity

We then applied lateral compression on both iliac crests to close the anterior wedge and create a “greenstick” fracture at the posterior osteotomy sites, leaving the posterior cortex intact creating a periosteal hinge (Figure 5A and 5B).

The wounds were then packed and closed provisionally with nylon to allow urology to perform their part of the procedure. Once urology was finishing their portion and getting ready for the final closure, we placed the INFIX system.

Skeletal Stabilization

A. A multi-axial pedicle screw (7.5 x 60 mm) was placed under fluoroscopic guidance on both hips just superior to the AIIS (similar area where one of the external fixation system Schanz screws would be located with the Sponseller technique). The screw head lay superficial to the fascia (Figure 6A, 6B, 6C, 6D).

B. A 6.0-rod was bent to accommodate the patient’s circumference and inserted after creating a tunnel subcutaneously, connecting both screws (Figure 7).

C. We sequentially compressed the rod on each side to allow for rotational closure of the pelvis (Figure 8A and 8B).

D. Once the provisional tightening was performed, and the adequate correction was obtained, the screws on both sides were torqued and the extra rod was cut.

E. We then compressed the wedge osteotomies bilaterally to allow posterior iliac closure and placed two

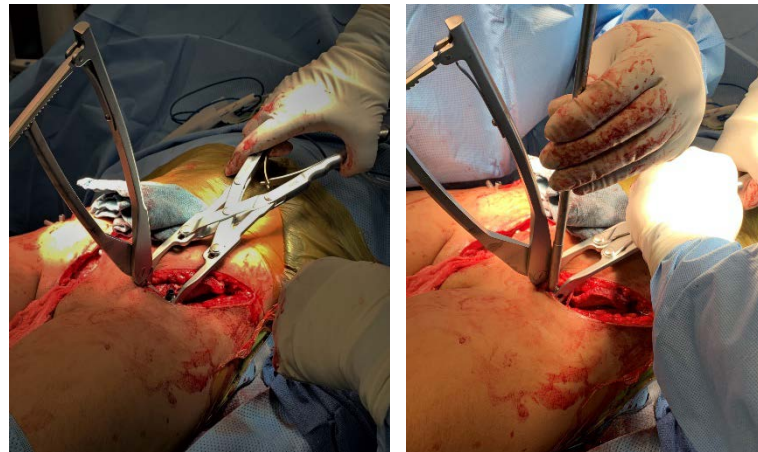
cortical screws on each iliac wing to connect with the supra-acetabular osteotomy sites. We used fluoroscopy to verify adequate screw placement (Figure 9A and 9B).

F. The incisions were copiously irrigated, bone graft was added as needed, and the wounds were closed in layers by the urology team (Figure 10).

Case Outcome

The preoperative imaging of this 12-year-old female patient with bladder exstrophy revealed 6.3 cm of pelvic diastasis with typical bilateral acetabular retroversion. The immediate postoperative films revealed pelvis diastasis correction to 1.6 cm as well as correction of bilateral acetabular retroversion. There were no signs of infection, bladder injury, immediate loss of symphysis reduction, neuropraxia, or vascular injury noted postoperatively.

The patient spent 2 days in the intensive care unit due to the extent and length of the combined procedures. She was extubated on the first postoperative day (POD). She was then transferred to an intermediate care unit for the remainder of her hospital stay. She was sitting up in bed and non-initiated on the second POD. The patient was permitted to sit at bedside and transfer to a chair starting the third and fourth POD, respectively. Her total length



Figures 8A and 8B. Clinical photos demonstrating compression of rod for pelvic closure

of stay was 11 days, as she required serial bladder irrigations. She was discharged with a reclining wheelchair and was made non-weight bearing.

On the subsequent follow-up visit, bony callus was visible at 6 weeks. Callus was deemed mature and pelvic ring stable for full weight-bearing as tolerated starting at 12 weeks. At the 7-month office visit, the patient was fully ambulatory and pelvis films revealed maintenance of pelvic correction without migration or loosening of implants. She demonstrated bilateral full range of motion of the hips without pain. The patient was also continent and able to self-catheterize. She in fact mentioned that she had been running and dancing without any pain. The patient underwent INFIX implant removal 2 weeks later.

The patient was seen 3 months after removal of the INFIX device. Pelvis AP radiograph taken revealed anterior symphysis diastasis of 2.9 cm (Figure 11). This represented a 1.3 cm increase since INFIX removal, but a 3.4 cm overall decrease from initial presentation. The patient again reported no pain with full range of motion. Her incisions were well-healed without signs of infection (Figure 12). The patient continued to be continent and was able to self-catheterize.

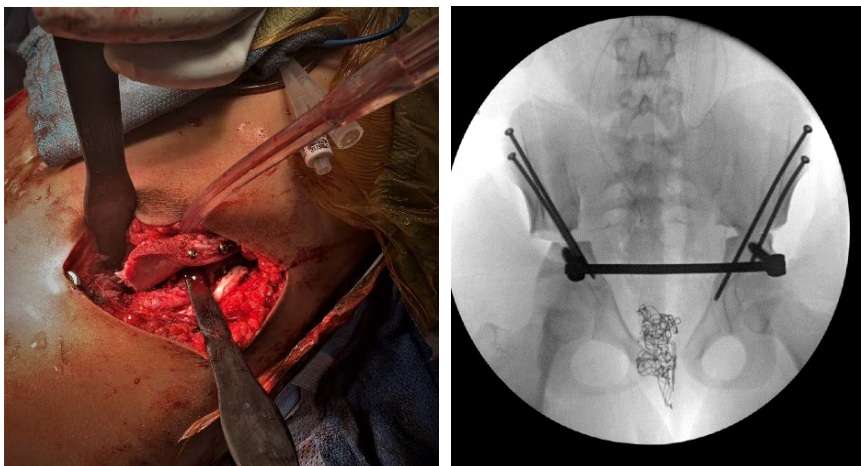


Figure 9. Clinical (A) and radiographical (B) images demonstrating supra-acetabular osteotomy fixation with cortical screws

Discussion

Patients with bladder exstrophy present with the bladder everted and extruded across the inferior abdomen. Orthopaedically, these patients are known to have a large diastasis that progress into adulthood. They also have an average of 12 degrees external rotation of the iliac wings, 13 degrees bilateral acetabular retroversion beyond normal, and 30% foreshortened pubic bones.¹ Surgical treatment involves coordination with multiple surgical specialties, especially orthopaedics and urology services. The pelvis deformity (pubic diastasis) must be corrected in order to reduce tension of surrounding soft tissues to facilitate abdominal/bladder closure, pelvic floor muscles function, eventual bladder continence, and decreased postoperative dehiscence.^{5,9}

Sponseller's technique involves bilateral vertical posterior iliac wedge osteotomies that are unicortical and close to the sacroiliac joint. Additionally, bilateral supra-acetabular osteotomies (Salter-type) are performed to achieve pelvic floor approximation by facilitating closure of the pelvic ring and symphysis pubis and correcting the acetabular retroversion.^{5,6} The authors used an external fixator system to maintain reduction of the supra-acetabular fragments. However, external fixators are cumbersome, unsightly, and have an increased risk for pin tract infection due to its location

Figure 10.
Surgical incisions before final closure



Figure 11. *Final anteroposterior (AP) pelvis radiograph demonstrating reduction after removal of implant.*

and association to bladder defects, which may cause exposure to irritants and contaminants such as urine and feces. In addition, external fixators are inherently bulky and can cause difficulties with sitting, transfers, wearing seatbelts, and sleeping, as the patients can only sleep in the supine position. These oversized devices also make clothing a potential problem, as the external fixator overlies the inguinal area.⁷

We described our initial experience with a novel anterior subcutaneous pelvic fixation technique (INFIX) in a case of a female undergoing bladder exstrophy repair. The INFIX technique is based on standard orthopaedic techniques with supra-acetabular screws at the ASIS area and a subcutaneous rod that is bent to adjust to the circumference of the patient to allow easy passage without compressing the inguinal fascia. The construct is then given compression to successfully close and fix the pubic diastasis after osteotomies have been performed. The INFIX did not interfere with final urology closure and allowed for easy postoperatively

Figure 12. Healed surgical incisions during final clinic appointment



patient perineal care, and management of the urology drains and irrigation devices.

The INFIX system has slightly higher translational stiffness and significantly higher rotational stiffness in comparison to external fixators due to a shorter lever arm of the construct, which inherently decreases tension at the osteotomy sites.¹⁰ This inherent stability allows for early mobility and potentially less pain. The INFIX frame also allows patients to sit upright, turnover from side to side, and lie in the prone position.⁷ The system neglects the need for anterior plating which can irritate the bladder and the skin at the closure site. At the same time, by obviating anterior plating, it potentially allows the symphysis pubis to stretch if the patient becomes pregnant. We did experience minor loss of pubic symphysis diastasis correction after the removal of the implant, which was also seen regularly in other series.^{5,6} However, this has not shown any clinical significance in our case. It is noteworthy to identify that both INFIX and external fixator techniques yield similar time to union, which is approximately 3 months.

Cost analysis also revealed another advantage of INFIX over external fixation systems which can become costly with increasing complexity of the constructs. In our institution, the average cost for an external fixator system is \$6,500 which is four times higher than INFIX, which averages \$1,750.

Summary

INFIX is a novel fixation technique that is well tolerated and an effective alternative for anterior pelvic ring fixation and stabilization in older bladder exstrophy patients. In addition to the strength of the fixation, all these benefits, whether cosmetic, functional, or monetary, can also add a potential psychological benefit to the patient and the caregiver.

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