SUBSPECIALTY PROCEDURES

BILATERAL ANTERIOR INNOMINATE OSTEOTOMY FOR BLADDER EXSTROPHY

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Published outcomes of this procedure can be found at: *J Bone Joint Surg Am.* 2001 Feb;83(2):184-93.

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JOURNAL OF BONE AND JOINT
SURGERY, INCORPORATED

Abstract

Background: Bladder exstrophy is a congenital condition that affects the genitourinary and musculoskeletal systems, and less commonly affects the intestinal system, with cloacal exstrophy. This condition results from abnormal migration of the mesenchyme, between the endoderm and ectoderm, leading to anterior rupture of the cloacal membrane. Numerous osseous morphologic changes are observed in bladder exstrophy. Rotational anomalies include external rotation of the posterior part of the pelvis and iliac wings, on average 12°, and acetabular retroversion¹⁻³. Although various osteotomy types have been described for initial bladder exstrophy closure, the anterior approach has demonstrated positive outcomes in improving daytime continence, gait, and correction of the diastasis⁴. Thus, the anterior iliac osteotomy provides an effective method to help close the pelvic ring and decrease stress on the anterior abdominal wall during exstrophy closure. In addition, this technique promotes continence by reconfiguring, and thereby restoring, the fibrous symphyseal bar and pelvic floor musculature⁵.

Description: The steps of the procedure include (1) preoperative planning, (2) patient positioning, (3) incision, (4) identification of the lateral femoral cutaneous nerve, (5) subperiosteal dissection of the iliac wing, (6) guide pin placement and anterior osteotomy, (7) posterior hinge osteotomy (for cloacal exstrophy and for patients ≥2 years old), (8) external fixator pin placement, (9) anterior internal fixation of the pubic symphysis (for cloacal exstrophy and for patients ≥2 years old), and (10) resumption of the urologic procedure followed by wound closure and application of external fixator.

Alternatives: Numerous previous techniques for osteotomies in bladder exstrophy have been developed, starting with Shultz in 1958, who recognized the importance of bringing the pubic bones together for gait correction in exstrophy repair⁶. O'Phelan was the first, to our knowledge, to document outcomes of this bilateral posterior osteotomy technique to reduce tension from the externally rotated iliac bones and widened pubic symphysis in a 2-stage bladder exstrophy closure⁷. Other approaches have included an oblique iliac wing osteotomy and pubic ramotomy, described by Frey and Cohen in

Disclosure: The authors indicated that no external funding was received for any aspect of this work. On the **Disclosure of Potential Conflicts of Interest** forms, which are provided with the online version of the article, one or more of the authors checked "yes" to indicate that the author had a relevant financial relationship in the biomedical arena outside the submitted work (<http://links.lww.com/JBJS/ST/A232>).

1989⁸. However, the latter approach inadequately restores the pelvic osseous relations except in female newborns who would have a small diastasis after manual rotation of the pelvis.

Rationale: This procedure has several advantages over the prior conventional posterior approach. These include better approximation and improved mobility of the pubic rami at the time of closure, prevention of vertical migration of the hemipelvis, direct visual placement of an external fixator and adjustment postoperatively, and no requirement for turning the patient during the operation. In addition, this procedure allows for adjunctive posterior osteotomy from the anterior approach to provide adequate closure in those with cloacal exstrophy, prior failed closure, or extreme diastasis of >6 cm⁹.

Introductory Statement

Bilateral anterior innominate osteotomy for bladder exstrophy allows a tension-free closure of the bladder and abdominal wall and is highly successful in restoring continence, with more control of the pelvis compared with alternative approaches.

Indications & Contraindications

Indications

- Substantial diastasis of >4 cm.
- Late or failed closure of bladder exstrophy in a patient who is >28 days old.
- Aesthetic purposes for a patient who is >8 years old.
- Females with bladder exstrophy and accompanying cervical prolapse.
- Cloacal exstrophy (typically performed when a child is >18 months old).

Contraindications

- None.

Step-by-Step Description of Procedure

Step 1: Preoperative Planning (Video 1)

Assess for hip dysplasia and malformations of the sacroiliac joint that are common in cloacal exstrophy.

- Make an anteroposterior radiograph of the pelvis and measure the pubic diastasis (Fig. 1).

Fig. 1

Fig. 1 Preoperative anteroposterior radiograph demonstrating a pubic diastasis of approximately 6 cm as indicated by the red arrow.

Video 1 Introduction, background, indications, and preoperative planning. AIIS = anterior inferior iliac spine. (Diagrams reproduced from: Sponseller PD, Bisson LJ, Gearhart JP, Jeffs RD, Magid D, Fishman E. The anatomy of the pelvis in the exstrophy complex. J Bone Joint Surg Am. 1995 Feb;77[2]:177-89, and Sponseller PD, Jani MM, Jeffs RD, Gearhart JP. Anterior innominate osteotomy in repair of bladder exstrophy. J Bone Joint Surg Am. 2001 Feb;83(2):184-93.)

Step 2: Patient Positioning (Video 2)

Prepare the patient preoperatively to optimize visualization.

- Discuss with the anesthesiologist about the need to insert a tunneled epidural catheter or peripherally inserted central catheter line.
- Drape the patient below the costal margin and ensure that the bladder is covered in a sterile fashion.
- Cover the legs for warmth.

Video 2 Patient positioning.

Step 3: Incision (Video 3)

Make bilateral oblique incisions 1 cm inferior to the anterior superior iliac spine (ASIS).

- Identify the ASIS.
- Outline the incision approximately 5 to 10 mm proximal to the ASIS.
- Cut the skin with a scalpel.

Video 3 Incision. ASIS = anterior superior iliac spine.

Step 4: Identification of the Lateral Femoral Cutaneous (LFC) Nerve (Video 4)

Isolate and protect the LFC nerve.

- Incise the fascia and identify and then follow the LFC nerve inferior to the ASIS, running laterally and distal to the ASIS.
- Retract the LFC nerve and its branches medially.
- Develop the tensor sartorius interval laterally up to the ASIS.

Video 4 Identification of the lateral femoral cutaneous (LFC) nerve.

Step 5: Dissection of the Iliac Wing (Video 5)

Expose the iliac wing using a subperiosteal dissection.

- Create an iliac apophysis split, at most 1 cm, to visualize the tip of the iliac crest using an elevator.
- Dissect in the subperiosteal plane caudally to the pectineal tubercle and posteriorly to the sacroiliac joint.
- Place retractors medial and lateral to the incision to protect the pelvic contents.
- Elevate the periosteum of the sciatic notch.

Video 5 Subperiosteal dissection of the iliac wing. SI = sacroiliac.

Step 6: Guide Pin Placement and Osteotomy (Video 6)

Insert a guide pin to facilitate the subsequent anterior osteotomy.

- Locate the ASIS and insert a guide pin transversely or with a slight downward angle, aiming for the top of the sciatic notch.
- Make a radiograph to confirm accurate placement of the guide pin.
- Use an oscillating saw to cut along the guide pin, exiting anteriorly at a point halfway between the ASIS and anterior inferior iliac spine (AIIS).
- Finish the cut with an osteotome to separate the proximal and distal fragments, on reaching the cortical bone.

Video 6 Guide pin placement and anterior osteotomy.

Step 7: Posterior Hinge Osteotomy (for Patients Who Are ≥ 2 Years Old or Those with Cloacal Exstrophy) (Video 7)

Create a mobile posterior cortical hinge.

- Continue the subperiosteal dissection over the medial aspect of the iliac wing posteriorly to the sacroiliac joint.
- Use cautery or bone wax to control bleeding from a nutrient vessel located in the middle of the wing.
- Use a rongeur or burr to remove the cortical and cancellous bone over the anterior portion of the ilium lateral to the sacroiliac joint, thereby creating a closing-wedge osteotomy vertically ≥ 1 cm from the sacroiliac joint.
- Cut with an oscillating saw until the iliac wings are free enough to hinge but are not vertically unstable.
- Use an osteotome to separate the distal cortical portion of the posterior iliac cortex.

Video 7 Posterior hinge osteotomy (for patients who are ≥ 2 years old or who have cloacal exstrophy).

Step 8: Placement of External Fixator Pins (Video 8)

Insert pins for the external fixator (Fig. 2).

- Internally rotate the distal segment and insert the first threaded fixator pin through the inferior aspect of the iliac wing parallel to the main transverse osteotomy to obtain bicortical fixation of the pelvis.
- Insert the second threaded pin anterior and parallel to the first pin.
- Insert the third pin proximal to the main transverse incision through the iliac wing with the tip on the iliac crest and directed between the iliac tables horizontally.
- Make an anteroposterior pelvic radiograph to confirm pin placement.

Fig. 2

Fig. 2 Intraoperative clinical photograph demonstrating accurate placement of the 3 external fixator pins when viewed superiorly over the patient who is oriented supine on the operating-room table. The first pin is inserted through the inferior aspect of the iliac wing. The second pin, lying anterior to the first, is placed in a parallel direction through the inferior iliac wing. Lastly, the third pin is inserted proximal to the other 2 pins between the iliac tables.

Video 8 Placement of external fixator pins.

Step 9: Anterior Internal Fixation of the Pubic Symphysis (After the Bladder Is Closed) (Video 9)

Perform anterior internal fixation of the pubic symphysis to improve symmetry and healing in patients who are ≥ 2 years old and in those with cloacal exstrophy.

- Insert a pubic screw through the superior pubic ramus in the channel of the pubis.
- Use fluoroscopy to ensure placement through the channel rather than penetrating the pubic ramus (Fig. 3-A).
- Use fixator screws affixed to a 2-hole plate for patients with cloacal exstrophy or prior failed treatments (Fig. 3-B).

Fig. 3

Fig. 3 Postoperative anteroposterior pelvic radiograph (**Fig. 3-A**) side-by-side with a clinical photograph (**Fig. 3-B**) of the anterior internal fixation with bilateral screw placement down the superior pubic rami, as denoted by the red arrow on the radiograph. The blue arrows indicate the external fixator pins held in place for the typical 6-week course postoperatively.

Video 9 Anterior internal fixation of the pubic symphysis (for patients who are ≥ 2 years old or who have cloacal exstrophy). AP = anteroposterior.

Step 10: Wound Closure and Postoperative Management (Video 10)

The external fixator bars can be used to manage the diastasis postoperatively.

- Close the pelvis with a horizontal mattress suture between the pubic bone on each side using number-2 nylon, which we prefer because it allows for a nice closure.
- Apply external fixator bars between the pins (Figs. 4-A and 4-B).
- Postoperatively, maintain the patient in the supine position with light skin traction for approximately 4 to 6 weeks until adequate callus is visualized over the osteotomy sites (Fig. 5). The time in traction allows for gradual movement of the soft tissues to accommodate the urological reconstruction.
- Make an anteroposterior pelvic radiograph at 7 to 10 days postoperatively to assess the symphyseal diastasis.

Fig. 4

Fig. 5

Fig. 4 Clinical photographs from a lateral (**Fig. 4-A**) and anterior view (**Fig. 4-B**) of the external fixator in place postoperatively.

Fig. 5 Postoperative photograph of a patient with bladder exstrophy in light Buck traction.

Video 10 Wound closure and postoperative management with light Buck traction.

Results

Anterior innominate osteotomies may be an adjunct of both classic and cloacal bladder exstrophy reconstruction, and they have shown substantial positive outcomes with limited complications⁴. In the original cohort of 82 patients, a 65% improvement was observed in mean diastasis immediately postoperatively before settling to approximately 27% at 5 years of follow-up. Comparatively, those with cloacal exstrophy ultimately achieved a similar rate of 28% correction at the 5-year time point, despite an initial pubic diastasis that was 3 cm larger (Fig. 6). Because of the improved position of the sling of the pelvic floor muscles and not just symphyseal approximation alone, this modern staged technique has been shown to improve the chances of attaining urinary continence. In the same cohort, 74% of the children were able to reach their goal of continence.

Risk of recurrent symphyseal diastasis has long been a concern, and as shown in the original study, was significantly more likely in the first 3 postoperative months and among those who underwent correction within the first 6 months of life^{4,9}. However, the underlying mechanism for recurrent diastasis remained unclear. Most recently, Kenaway et al., in 2014, explored this phenomenon in a cohort of 51 patients with classic exstrophy, and subdivided the group into those with and those without osteotomies to evaluate the role of the modern osteotomy technique on pelvic morphology at long-term follow-up (mean, 10 years)¹⁰. Their results demonstrated that recurrent diastasis was a result of continued transverse growth of the pelvis. Neonatal osteotomies functioned to provide sustained improvement in pelvic shape, irrespective of age at osteotomy, primarily via rotational correction of the ischiopubic external rotation deformity, allowing for ultimately better approximation of the pubic bones (Fig. 7).

Results from our institution have documented the possible complications, and their rates, associated with this technique¹¹. In a cohort of 624 patients over a 14-year period, 4% of patients developed a complication. Of those complications, 50% were neurologic, primarily transient femoral, sciatic, or peroneal nerve palsies attributed to the increased tension on the inguinal ligament after medial correction of the pubis. Nineteen percent were osseous complications, including nonunion, proximal migration, or asymmetry, which the authors suspected could have been reduced if there had been adequate osseous apposition, including the use of bone graft, at the osteotomy site. Infections around the surgical site were observed in 7%, with equal breakdown between early and late development.

Fig. 6

Fig. 7

Fig. 6 Line graph illustrating the mean symphyseal diastases in patients with classic (open circles) and cloacal (closed diamonds) exstrophy at 4 time points, ranging from the preoperative evaluation to the latest follow-up (F/U; mean, 3.5 years) after anterior osteotomy. Also shown is the estimated curve of symphyseal diastasis for patients with classic exstrophy (open squares) who had not undergone the osteotomy. (Reproduced from: Sponseller PD, Jani MM, Jeffs RD, Gearhart JP. Anterior innominate osteotomy in repair of bladder exstrophy. *J Bone Joint Surg Am.* 2001 Feb;83[2]:184-93.)

Fig. 7 Diagram of osseous changes observed in bladder exstrophy, including external rotation of the ilia, acetabular retroversion, and shortening of the pubic rami. (Reproduced from: Sponseller PD, Bisson LJ, Gearhart JP, Jeffs RD, Magid D, Fishman E. The anatomy of the pelvis in the exstrophy complex. *J Bone Joint Surg Am.* 1995 Feb;77[2]:177-89.)

Pitfalls & Challenges

- Limit tension on the inguinal ligament after medialization of the pubis to prevent femoral nerve complications using a posterior closing-wedge osteotomy.
- Carefully dissect around the sciatic notch and avoid pressure at the knees to minimize sciatic and peroneal nerve palsies.
- Do not wrap the patient's legs too tightly during traction to prevent serious complications, such as compartment syndrome and pressure sores.
- Avoid levering downward with the osteotome when finishing the cut near the sciatic notch to prevent propagation of the crack, until the osteotomy is complete.

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