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Newborn exstrophy closure without osteotomy: Is there a role?

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Summary

Introduction
Recent articles document successful classic bladder exstrophy (CBE) closure without osteotomy. Still, many patients require osteotomy if they have a large bladder template and pubic diastasis, or non-malleable pelvis.

Objective
To understand the indications and outcomes of bladder closure with and without pelvic osteotomy in patients younger than 1 month of age.

Methods
An institutional database of 1217 exstrophy-epispadias patients was reviewed for CBE patients closed at the authors' institution within the first month of life. Patient demographics, closure history, pubic diastasis distance, bladder capacity, and outcomes were recorded and compared using chi-square tests between osteotomy and non-osteotomy patients. Failure was defined as bladder dehiscence, prolapse, vesicocutaneous fistula, or bladder outlet obstruction requiring reoperation. Bladder capacity >100 mL was deemed sufficient for bladder neck reconstruction (BNR).

Results
One hundred CBE patients were included for analysis: 38 closed with osteotomy (26 male, 12 female), and 62 closed without osteotomy (42 male, 20 female). There were four failed closures in the osteotomy group (2 dehiscence, 2 prolapse) and four failed closures in the non-osteotomy group (2 dehiscence, 2 prolapse). This corresponded to statistically equivalent rates of failure between the osteotomy and non-osteotomy groups (10.5% vs. 6.5%, $p = 0.466$). There was no statistically significant difference between the groups' ability to achieve bladder capacity sufficient for BNR (82% vs. 71%, $p = 0.234$).

Discussion
A successful primary bladder closure, regardless of the use of osteotomy, has been shown to be the single most important predictor of eventual continence. Because of the complexity of exstrophy manifestations, a multidisciplinary team approach is of the utmost importance. Based on our institutional experience, closure without osteotomy is considered when patients are <72 h of life, have a pubic diastasis <4 cm, malleable pelvis, and pubic apposition without difficulty. Rates of successful closure and attaining sufficient capacity for BNR were both statistically equivalent across groups. This retrospective study is limited by selection bias and the significant difference in follow-up time between groups. Nevertheless, as a high-volume exstrophy center this study draws from one of the largest cohorts available.

Conclusions
Regardless of the type of closure undertaken, there clearly is a role for newborn CBE closure without pelvic osteotomy in patients considered suitable for closure by both the pediatric urologist and orthopedic consultant. However, if there is any doubt concerning pubic diastasis width, pelvic malleability, or ease of pubic apposition, an osteotomy is highly recommended.

Table Urologic outcomes.

	Closed with osteotomy ($n = 38$)	Closed without osteotomy ($n = 62$)	p
Failed primary closure	4 (11%)	4 (7%)	0.466
Bladder capacity for bladder neck reconstruction	31 (82%)	44 (71%)	0.234

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Introduction

The treatment of children with exstrophy-epispadias complex (EEC) remains one of the more challenging areas in the field of pediatric urology. Historically, surgical management has been focused on preservation of renal function and achieving continence [1]. With an improved understanding of the anatomy and pathophysiology, further treatment refinements have led to significant improvements in outcomes over the past several decades [2,3]. A successful primary closure is crucial for bladder growth and eventual continence. Ongoing work at the authors' institution concerning the cost of closure in classic bladder exstrophy found that the cost of successful closure was relatively higher in patients who had undergone a prior failed closure than in those who underwent a successful primary closure, resulting in a US$19,677 relative increase in inpatient hospital costs entirely distinct from the absolute cost of an additional closure. The use of pelvic osteotomies at the time of primary closure has been associated with improved rates of success in all types of closures [4]. Osteotomies significantly decrease the tension across the pubic symphysis and abdominal closure, and are thought also to allow for deeper placement of the bladder and posterior urethra into the pelvis, presumably resulting in the observed improvements in outcomes [5]. Proper immobilization of the pelvis following osteotomy, along with adequate sedation and pain control, have been shown to decrease the rate of postoperative complications and failure of closure [5]. In the aforementioned submitted cost study, the authors found that when accounting for important surgical covariates, osteotomy, despite all its benefits, was found to not significantly impact the cost of care.

Based on these observed benefits, pelvic osteotomy has traditionally been employed in primary closures, and generally considered mandatory in those patients with a large bladder plate, wide pubic diastasis (>4 cm), and/or non-malleable pelvis [6]. Recent improvements in the accuracy of fetal exstrophy diagnosis have increased the number of these patients seeking prenatal consultation and delivery at exstrophy centers, thus decreasing delays in referral. This technology has increased the proportion of newborns available for primary closure in the newborn period when the pelvic bones remain quite malleable, and the routine use of osteotomy in this setting has recently come into question. Several recent studies have demonstrated the potential for classic bladder exstrophy (CBE) closure without osteotomy in the newborn period [7,8]. However, these studies did not compare outcomes between one newborn group with osteotomy and another without osteotomy. To understand the utility of osteotomy in the newborn, this study presents the experience of a single referral center with CBE closure with and without osteotomy.

Methods and materials

An institutional review board-approved, prospectively maintained database of 1217 exstrophy-epispadias patients was screened for CBE patients closed within the first month of life at the authors' institution since 1975. All patients were closed by one of two pediatric urologists with the modern staged repair of exstrophy (MSRE) approach. Patients were divided into two groups based on whether or not pelvic osteotomy had been performed at the time of closure. Patients underwent concomitant osteotomy during initial closure under the discretion of the surgeon with strong consideration of a wide pubic diastasis greater than 4 cm, inadequate malleability of the pelvic bones, ease of pubic apposition, and sacroiliac ligament laxity when examined within 48 h of life. All patients receiving osteotomy had bilateral anterior iliac and transverse innominate osteotomies performed by the same pediatric orthopedic surgeon. All osteotomy patients were immobilized following closure with an external fixation device and modified Buck's traction. All patients closed without osteotomy were immobilized with modified Bryant's traction. To ensure proper immobilization, a pediatric anesthesiologist provided postoperative analgesia via tunneled caudal epidural catheters and sedation by diazepam as previously described [9]. Patients were excluded if primary closure was performed at an outside institution.

Patient demographics, closure history, pelvic osteotomy history, preoperative pubic diastasis measurement, type of osteotomy and pelvic immobilization at initial closure, type of hardware use for pelvic stabilization, most recent pubic diastasis measurement, length of follow-up, and outcomes (bladder capacity, closure failure) were recorded and compared for statistical significance. The pubic diastasis difference was obtained by subtracting the most recent pubic diastasis from the pre-closure pubic diastasis measurement. Special attention was given to closure failure (recognized as wound dehiscence, bladder prolapse, vesicocutaneous fistula, and bladder outlet obstruction). Descriptive variables are presented as mean $\pm$ standard deviation. Variables were analyzed using the Student *t* test and chi-square test with $p = 0.05$ the cut-off for significance. All statistical analysis was performed with Microsoft Excel 2010 (Redmond, WA, USA) and SPSS 16 (Chicago, IL, USA).

Pelvic radiographs were taken either the day before or day of osteotomy and were evaluated by a board-certified pediatric radiologist to measure pubic diastasis distance electronically to the tenth of a millimeter. Since some preoperative films were done before the advent of online radiology archives, those that could not be found in the hospital archives were excluded from the diastasis comparisons. Following closure, patients undergo annual gravity cystograms, the results of which help determine further continence management. A bladder capacity greater than 100 mL was deemed sufficient for bladder neck reconstruction (BNR). Additionally, these cystogram images provide current pubic diastasis measurements.

Results

Of the 848 CBE patients reviewed, 100 met inclusion criteria: 38 (26 male, 12 female) were closed with osteotomy, and 62 (42 male, 20 female) were closed without osteotomy (Table 1). There was a significant difference in the age at which they underwent primary closure as the patients who received osteotomy were 8.7 $\pm$ 8.3 days old while the patients closed without osteotomy were 2.9 $\pm$ 3.1 days old ($p < 0.001$). This likely reflects prenatal diagnosis

Table 1 Patient demographics and closure history.

	+Osteotomy ($n = 38$)	−Osteotomy ($n = 62$)	p
Male (%)	26 (68)	42 (68)	0.562
Age at primary closure (days)	8.68 ± 8.30	2.90 ± 3.12	<0.001
Pre-closure pubic diastasis (cm)	3.91 ± 0.75	3.21 ± 0.95	0.004
Most recent pubic diastasis (cm)	4.97 ± 1.73	4.36 ± 1.13	0.094
Diastasis difference (cm)	1.06 ± 1.59	1.15 ± 1.50	0.821
Time between diastasis measurements (yrs)	5.96 ± 4.43	5.55 ± 3.94	0.707
Length of hospital stay (days)	35.81 ± 9.68	33.54 ± 5.28	0.84
Length of follow-up (yrs)	13.42 ± 7.31	8.93 ± 6.65	0.003

and delivery in the authors' hospital. While there was no difference in the length of hospital stay between the two groups, patients receiving osteotomy had a significantly longer follow-up than non-osteotomy patients (13.4 vs. 8.9 years, $p = 0.003$).

Patients undergoing osteotomy also had a significantly wider pre-closure diastasis (3.91 ± 0.75 cm) than patients who did not receive an osteotomy (3.21 ± 0.95 cm; $p = 0.004$). The two groups did not significantly differ in the most recent measurement of their pubic diastasis, the overall difference in pubic diastasis, or the length of time between pre-closure and most recent post-closure diastasis measurements.

There were four failed closures in the osteotomy group (2 dehiscence, 2 prolapse) and four failed closures in the non-osteotomy group (2 dehiscence, 2 prolapse). There was no significant difference in failed closures between the two groups (11% osteotomy vs. 7% non-osteotomy, $p = 0.466$). There was also no significant difference in the percentage of patients with bladder capacity sufficient for BNR (82% osteotomy vs. 71% non-osteotomy, $p = 0.234$).

Discussion

Refinements in the treatment of bladder exstrophy have allowed a shift in goals from mere survival to improving quality of life through urethral continence, and improved cosmesis and functional outcomes. Although there is ongoing discussion with regards to achieving continence in exstrophy patients, a successful primary bladder closure, regardless of the use of osteotomy or type of repair undertaken, has been shown to be the single most important predictor of eventual continence [10]. This has become the primary goal of exstrophy management. Because of the complexity and variability of exstrophy manifestations among patients, a multidisciplinary team approach is of utmost importance to achieve that goal. From preoperative consultation to post-surgical care, a dedicated and experienced team consisting of a pediatric radiologist, pediatric orthopedic surgeon, pediatric urologist, pain control team supervised by a pediatric anesthesiologist, and nurse specialists is essential to best manage exstrophy patients. Institutions unable to offer this multidisciplinary team approach are encouraged to refer care to higher volume institutions better equipped to manage these patients and their potential complications.

Pelvic osteotomy has been associated with improved success rates of primary closure [5]. Therefore, pelvic osteotomy has become considered an essential element of primary closure. It has been noted that the newborn pelvis remains relatively lax and malleable up to 72 h, an effect thought to be mediated by the persistence of maternal oxytocin [11]. Indeed, Mushtaq et al. [7] demonstrated the feasibility of managing newborn CBE closures solely on the surgical ward and without the use of pelvic osteotomy or prolonged pelvic immobilization. Opting for postoperative management on the ward reduced the number of cases managed in the neonatal intensive care unit (ICU), thus reducing higher costs associated with ICU care [7]. However, without disclosing their cohort's diastasis measurements it is unknown if the conclusion can be applied to the CBE population at large [12].

In this present study, diastasis distance did play a role in the decision to use osteotomies during primary closure, as the patients receiving an osteotomy had a significantly greater diastasis than the non-osteotomy group. It also appears that age at the time of closure affected the decision to employ osteotomies, with the mean age for the osteotomy group falling well beyond the 3-day period when effects of maternal oxytocin are still present, presumably keeping the bony pelvis malleable [1,11]. Based on our institutional experiences, the following criteria have been recommended to define those newborns who should receive an osteotomy at the time of closure: patients greater than 72 h of life, with a wide pubic diastasis (>4 cm), non-malleable pelvis, large bladder template, and difficulty in pubic apposition [6]. With these factors in consideration, both the pediatric urologist and pediatric orthopedic surgeon should perform a physical examination under anesthesia to determine if the pelvic ring is suitable for closure without osteotomy. It is when these criteria are met and a consensus between both experienced surgeons is reached, should newborn closure without osteotomy be considered. Otherwise, osteotomy use is encouraged to achieve successful closure by decreasing tension across the abdominal wall, lowering morbidity, and decreasing the rate of failed closures [5,13].

Notably, the outcome measures of rates of successful closure, and rates of attaining sufficient capacity for BNR, were both statistically equivalent across groups with and without osteotomy. Given that the osteotomy group was made up of older infants with greater diastasis distance, they would be expected to have inferior outcomes. The

fact that they demonstrated equivalent outcomes suggests a strong benefit of the treatment, seemingly leveling the playing field. Alternatively, if one discounts these effects of selection bias, and instead considers the two groups equal, then the equivalent outcomes may be taken as an argument against the routine use of osteotomies in newborn closures. This goes along with data by Stec et al. [14], who looked at closures with and without osteotomy evaluated by both pre-closure and post-closure three-dimensional magnetic resonance imaging of the pelvis. Surprisingly, the post-closure pelvic floor anatomy was the same with and without an osteotomy. This underscores the fact that adequate pelvic floor alignment can be achieved in early closures with or without pelvic osteotomy. However, the effect of proper pelvic floor anatomy on the biomechanics of continence is still unknown. Schaeffer et al. [15] reported on a group of complete primary repair of exstrophy patients with a successful primary closure referred for bladder neck reconstruction and found that those who achieved continence were closed as a newborn with pelvic osteotomy. This may be specific for this type of repair only and more studies are needed.

There are several important limitations to this study. In addition to the strong effects of selection bias, the significantly shorter follow-up for the non-osteotomy group may not have been sufficient to observe late failures or significant bladder capacity for BNR. Therefore, these data require updating after further follow-up. Not all radiologic studies were electronic, so a single radiologist could not review all diastasis measurements for the comparison of baseline characteristics. Radiographic reports were used for some diastasis measurements. Despite this, it was still not possible to obtain all of the diastasis measurements; therefore, some analysis was completed with several data points missing. The use of diastasis difference between the two groups may also be confounded since there is no consistency in the timing of postoperative diastasis measurements. However, the similar average of time following measurements between the two groups can help infer that on average the measurements were performed in a similar time frame. In addition, the rarity of CBE leads to small sample sizes and requires many years of referrals, subjecting the analysis to historical changes in perioperative and general medical care. Still, as a center with a large exstrophy volume, this study draws from a cohort that is likely larger than most others available. Future research should not only expand on the size and follow-up time of the cohort, but also incorporate data from other institutions as well. Ideally these efforts should also include objective evaluations of bladder function (urodynamics), quality of life data, and basic science studies examining bladder smooth muscle cells to make more definitive conclusions.

Conclusion

Regardless of the type of closure undertaken, there clearly is a role for newborn CBE closure without a pelvic osteotomy in patients less than 72 h of life, with a pubic diastasis <4 cm, and a malleable pelvic ring considered suitable for closure by both the pediatric urologist and orthopedic consultant. However, if the combined surgical team has any doubt concerning the pubic diastasis width, pelvic malleability, or ease of pubic apposition, an osteotomy is highly recommended at the time of closure during the newborn period to optimize successful outcomes.

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Conflict of interest

None.

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