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Analysis of risk factors affecting the prognosis of external fixation in the treatment of unstable pelvic fractures in children: a retrospective study of 96 patients

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Abstract

Background To investigate the efficacy of external fixation in treating unstable pelvic fractures in children and identify risk factors for poor prognosis.

Methods A retrospective study was conducted on children with unstable pelvic fractures treated surgically at our hospital from January 2006 to June 2022. All patients received external fixation, and those with vertical instability underwent postoperative limb traction. Data collected included gender, age, injury mechanism, associated injuries, imaging results, operation time, blood loss, pelvic reduction status, complications, and functional recovery. Variables were analyzed using multiple linear regression to explore risk factors for poor prognosis.

Results The study included 96 patients (62 males, 34 females) with an average age of 95.7 ± 50.3 months. Injury mechanisms were mainly traffic accidents (82.3%) and falls (14.6%). There were 47 cases of Tile B fractures and 49 cases of Tile C fractures. Surgeries were successful with an average operation time of 55.6 ± 27.3 min and blood loss of 6.3 ± 4.7 ml. Immediate postoperative Matta reduction quality was excellent in 91.7% of cases. Postoperatively, 46 patients underwent limb traction for an average of 9.3 ± 1.4 weeks. The average follow-up duration was 29.3 ± 11.7 months, and fracture healing time was 8.6 ± 1.1 weeks. At the final follow-up, 83.3% had excellent or good Cole pelvic function scores. WeeFIM scores indicated complete independence in 71 cases, conditional independence in 13, and conditional dependence in 12. Multiple linear regression identified age, Tile classification, and immediate postoperative displacement as independent predictors of prognosis. Patients aged ≥ 13 years, with Tile C fractures, and immediate postoperative displacement ≥ 8 mm had lower Cole scores.

Conclusions External fixation combined with lower limb traction effectively treats unstable pelvic fractures in children, with most patients having a favorable prognosis. Assessment of age, fracture type, and reduction quality is essential. Enhanced postoperative follow-up and functional exercises are recommended for older children, those with

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Tile C fractures, and those with significant immediate postoperative displacement. Clinicians should consider these factors to improve outcomes.

Level of evidence III

Keywords Unstable pelvic fracture, Children, External fixation, Prognostic risk factors, Age

Background

Pelvic fractures refer to fractures occurring in one or more parts of the ilium, pubis, or ischium and are commonly associated with high-energy injuries such as falls from heights, traffic accidents, and high-risk sports activities [1, 2]. Pelvic fractures are often associated with significant mortality due to the complex anatomy of the pelvis and the potential for severe related injuries. Mortality rates vary widely depending on the severity of the fracture and the presence of associated complications, ranging from 10% to as high as 50% in cases of hemodynamic instability [2, 3]. These injuries frequently involve concomitant damage to vital structures, including major blood vessels, the urinary system, and abdominal organs, resulting in a high risk of hemorrhage, visceral injury, and infection. Furthermore, long-term complications such as chronic pain, pelvic instability, and functional impairment emphasize the substantial clinical and social burden posed by pelvic fractures [3]. Early recognition and timely intervention are crucial for improving outcomes in these patients.

While pelvic fractures are relatively common in adults, accounting for about 3.9% of all fractures, they are rare in children, comprising only 2.0% of all pediatric fractures [3, 4]. Due to the immature skeletal structure of children, which includes a higher cartilage content, greater plasticity, and elasticity, the types of fractures, treatment methods, and prognosis differ significantly from those in adults [5, 6]. Most pediatric pelvic fractures achieve good outcomes with conservative treatment; however, some studies suggest that surgical fixation is necessary for unstable pelvic fractures in children [7]. Currently, there is ongoing debate regarding the surgical management of unstable pelvic fractures in children. Trauma orthopedic surgeons, drawing from adult pelvic fracture treatment experience, often favor open/closed reduction and internal fixation, while pediatric orthopedic surgeons tend to consider the unique characteristics of pediatric bones and prefer conservative treatment or closed reduction with external fixation [3, 8–11]. In recent years, with an increase in cases treated at our institution and the accumulation of experience, it has been observed that some pediatric patients with pelvic fractures treated with external fixation still experience poor outcomes. Moreover, research on the prognosis of surgical treatment for pediatric pelvic fractures is limited. Therefore, to investigate the risk factors affecting the prognosis of external fixation in the treatment of pediatric pelvic fractures, we collected and retrospectively analyzed the clinical data of pediatric patients with unstable pelvic fractures who underwent surgical treatment at our center.

Methods

General information

We conducted a retrospective study on data collected from patients with pelvic fractures treated at our hospital from January 2006 to June 2022. The inclusion criteria were: [1] age 0–18 years; [2] primary diagnosis of pelvic fracture; [3] Tile B or C type pelvic fractures; [4] surgical treatment with closed reduction and external fixation; [5] time from pelvic fracture to surgery ≤ 7 days; [6] The Advanced Trauma Life Support (ATLS) assessment was stable. The exclusion criteria were: [1] follow-up time < 24 months; [2] combined with metabolic bone diseases or pathological fractures; [3] history of pelvic or lower limb surgery; [4] open fractures or severe combined lower limb injuries; [5] American Society of Anesthesiologists (ASA) physical status level > IV. This study was approved by the medical ethics committee of our hospital, and an informed consent exemption was obtained (Approval No.: [2024]-E-118-R).

Surgical procedure

After anesthesia, patients were placed in a supine position on a traction bed. Using C-arm fluoroscopy, the bilateral anterior superior iliac spines were located. 1–2 cm above the anterior superior iliac spine, Schanz screws (diameter 4.0 mm, or 3.0 mm if preoperative CT showed the iliac width was less than 5 mm) were inserted into both iliac bones in the sequence of 2.0 mm Kirschner wire breaking through the cortex, drilling in Schanz screws, and connecting the pin-clamp. A rectangular frame was connected. The fracture was reduced under fluoroscopy by manually holding the rectangular frame: [1] Tile B type: The assistant compressed both iliac bones to correct horizontal separation, while the surgeon adjusted the frame to correct pelvic rotation; [2] Tile C type: The lower limb was tractioned to restore vertical displacement, then reduced as in Tile B type. Once satisfactory reduction was achieved (based on Matta pelvic reduction radiographic criteria: maximum displacement ≤ 4 mm for excellent, 5–10 mm for good, 10–20 mm for fair, > 20 mm for poor, with excellent and good considered

satisfactory), the external fixation system (Stryker® lower limb external fixation system) was connected and locked.

Postoperative management

Postoperatively, patients were kept on absolute bed rest with trunk immobilization. Blood transfusions were administered as needed based on laboratory indicators (hemoglobin ≤ 90 g/L or hematocrit ≤ 0.25). Schanz pin sites were disinfected daily with iodophor. Intravenous antibiotics (50 mg/kg, Q8h) and ibuprofen (10 mg/kg, Q8h, maximum single dose ≤ 0.4 g) were administered within the first 3 days postoperatively to prevent infection and manage pain. Tile C type patients received lower limb traction on the side with preoperative vertical displacement (weight 1/10 – 1/8 of body weight, traction time ≥ 8 weeks) to maintain vertical stability. Pelvic AP, inlet, and outlet X-rays were reviewed 3–5 days postoperatively.

Postoperative follow-up

Patients were followed up in the outpatient clinic at 1, 3, 6, 12, and 24 months postoperatively. Follow-up included pelvic AP, inlet, and outlet X-rays to assess fracture healing. The external fixation system was removed after fracture healing (defined as the disappearance of fracture lines on X-ray and negative squeeze & separation tests). At the final follow-up, Cole pelvic fracture functional rating and the WeeFIM (Functional Independence Measure) scores were recorded.

Evaluation indicators

Major Indicator: Cole pelvic fracture functional rating (Excellent: equal length and no rotation of both lower limbs, normal gait, no chronic pain at the fracture site; Good: length difference between lower limbs ≤ 2 cm, no rotation, generally normal gait, no chronic pain at the fracture site; Fair: length difference between lower limbs 2–4 cm, rotation < 15°, slight limping gait, mild chronic pain at the fracture site; Poor: length difference between lower limbs > 4 cm, rotation > 15°, limping gait, significant pain at the fracture site. Excellent = 1, Good = 2, Fair = 3, Poor = 4) [12].

Minor Indicators: [1] General Data: Gender, age (months), height, weight, BMI, cause of injury, associated injuries, STAMP score [2]. Surgical Data: ASA level, operation time, intraoperative blood loss [3]. Imaging Data: Tile classification of pelvic fractures, status of Y cartilage closure, Risser sign, pelvic asymmetry (absolute value of the difference between the bilateral sacroiliac joints from the iliac inferior edge to the medial center of the acetabulum base), pelvic deformity index (pelvic asymmetry/pelvic width from the iliac inferior edge to the medial center of the acetabulum base), Matta pelvic reduction radiographic criteria [13, 4]. Postoperative Follow-Up Data: Postoperative hospital stay, fracture healing time, complications, WeeFIM [14].

Statistical methods

The statistical software IBM SPSS 26.0 (IBM Corporation, Armonk, NY, USA) was employed for data processing and analysis. The Kolmogorov-Smirnov test was used to check the normality of measurement data. Normally distributed data were expressed as mean ± standard deviation (SD) and compared between groups using paired t-tests. Non-normally distributed measurement data were expressed as median (*Q1*, *Q3*). Count data were expressed as frequency, rate, or composition ratio. Pearson and Spearman correlation coefficients were used to analyze the correlation of variables. Influencing factors with $P < 0.1$ in univariate analysis were verified for independence using the Durbin-Watson method and then included in multiple linear regression analysis. $\chi 2$ tests were used to calculate the threshold points of independent predictors of external fixation treatment prognosis for pediatric pelvic fractures. Differences were considered statistically significant at $P < 0.05$.

Results

General data and preoperative imaging

Based on the case collection criteria, a total of 96 patients were included in this study. The causes of injury were traffic accidents in 79 cases (82.3%), falls from heights in 14 cases (14.6%), and high-risk sports in 3 cases (3.1%). All patients had associated injuries, including Cranial injuries: 31 cases (32.3%), primarily epidural hematomas; Thoracic injuries: 38 cases (39.6%), primarily lung contusions; Abdominal injuries: 56 cases (58.3%), primarily solid organ contusions; Urogenital system injuries: 21 cases (21.9%), primarily perineal lacerations; Musculoskeletal injuries: 28 cases (29.5%), primarily limb fractures. According to the Tile classification for pelvic fractures, there were 47 cases (49.0%) of type B fractures [B1: 8 cases (8.3%), B2: 21 cases (21.9%), B3: 18 cases (18.8%)] and 49 cases (51.0%) of type C fractures [C1: 26 cases (27.1%), C2: 18 cases (18.8%), C3: 5 cases (5.2%)]. The general preoperative data are detailed in Table 1.

Surgical and follow-up outcomes

All patients successfully underwent surgery, which was performed by the same chief surgeon. The average time from injury to surgery was 98.4 ± 43.2 h. The average duration of surgery was 55.6 ± 27.3 min, with an average intraoperative blood loss of 6.3 ± 4.7 ml. Immediate postoperative X-rays showed that, according to Matta's radiographic criteria for pelvic reduction, there were 69 cases rated as excellent, 19 as good, and 8 as fair, resulting in an overall excellent-good rate of 91.7%. The average displacement distance was 0.6 ± 0.5 cm. Pelvic asymmetry

Table 1 The preoperative baseline data of patients with pelvic fractures

Projects	Values
Male: Female	62 (64.6%):34 (35.4%)
Months of age (m)	95.7 ± 50.3 (21–190)
Height (cm)	135.4 ± 58.9 (90–183)
Weight (kg)	28.3 ± 11.0 (15–93)
BMI ($kg{\cdot}m^{-2}$)	23.7 ± 8.6 (18.5–27.8)
ASA level	2(2, 4)
STAMP score	3(1, 4)
Y-cartilage closure	
Open	47 (49.0%)
Closing	8 (8.3%)
Closed	21 (21.9%)
Risser Sign	0(0, 4)
Pelvic asymmetry (cm)	2.2 ± 0.9 (1.4–4.8)

BMI = body mass index; ASA = American Society of Anaesthesiologists; STAMP = Screening Tool for Assessment of Malnutrition in Paediatrics

and deformity indices significantly improved compared to preoperative values ($P < 0.001$) (Table 2).

Postoperatively, 46 patients underwent lower limb traction (38 cases with skin traction and 8 cases with skeletal traction) to control vertical instability. The average postoperative hospital stay was 11.7 ± 4.1 days, and the average traction duration was 9.3 ± 1.4 weeks. Four patients underwent unplanned surgeries (due to fixation displacement observed in X-rays on postoperative day 3), and 16 patients experienced pin site infections, which improved with wound dressing, iodophor wet compresses, and intravenous antibiotics. No severe perioperative complications, such as deep vein thrombosis of the lower limbs, cardiovascular or cerebrovascular events, hemodynamic instability, deep infections, or deaths, occurred.

All patients completed the follow-up, with an average follow-up duration of 29.3 ± 11.7 months. The average fracture healing time was 8.6 ± 1.1 weeks. At the final follow-up, pelvic asymmetry and deformity indices further improved compared to the immediate postoperative values ($P < 0.05$) (Table 2). The Cole pelvic fracture functional rating was excellent in 63 cases, good in 17 cases, fair in 10 cases, and poor in 6 cases. The WeeFIM scores indicated complete independence in 71 cases, conditional independence in 13 cases, conditional dependence (supervision and preparation) in 6 cases, conditional dependence (minimal physical assistance) in 5 cases, and conditional dependence (moderate physical assistance) in 1 case. Typical case images are shown in Fig. 1.

Analysis of related factors

Univariate correlation analysis showed that the Cole pelvic fracture functional rating was associated with the

Table 2 Comparison of pelvic asymmetry and deformity indices between preoperative, postoperative, and final follow-up stages

Projects	Pre-op	Post-op	Final follow-up	t_1 Values*	P_1 Values *	t_2 Values **	P_2 Values **
Pelvic asymmetry (cm)	2.2 ± 0.9	0.9 ± 0.4	0.6 ± 0.3	5.367	< 0.001	2.311	0.023
Pelvic deformity index	0.2 ± 0.1	0.1 ± 0.0	0.1 ± 0.0	3.483	< 0.001	2.100	0.039

* Comparison of pre-op and post-op

** Comparison of post-op and final follow-up

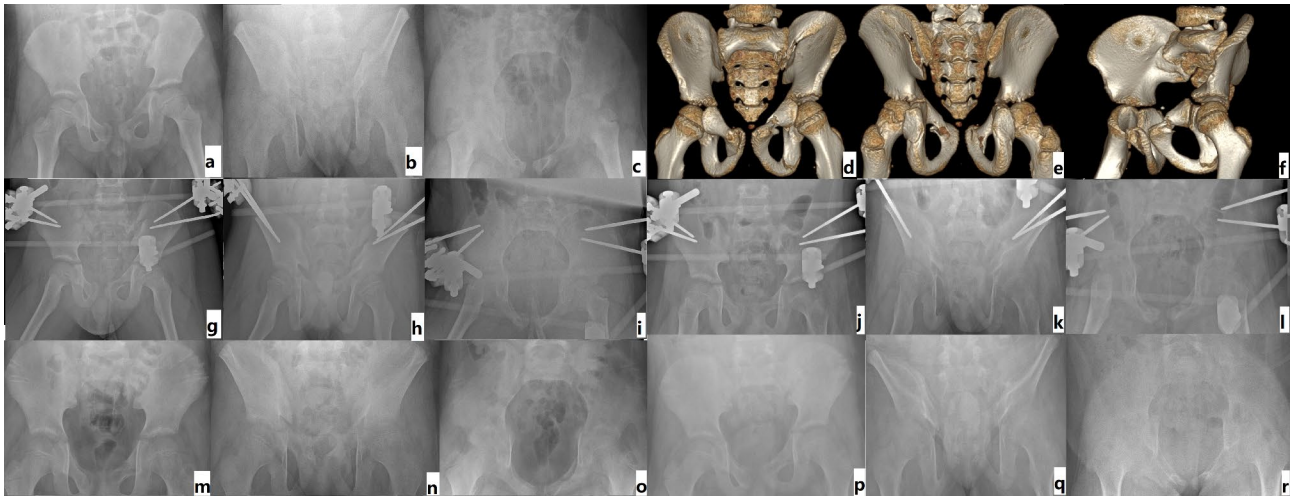

Fig. 1 Male, 8ys, caused by traffic accident, with a unilateral posterior pelvic ring Tile C-II injury and bilateral anterior ring injuries. **a**, **b**, **c**: Post-injury pelvic anteroposterior, outlet, and inlet X-rays; **d**, **e**, **f**: Post-injury CT 3D reconstruction; **g**, **h**, **i**: 1ws post-op pelvic anteroposterior, outlet, and inlet X-rays; **j**, **k**, **l**: 8ws post-op pelvic anteroposterior, outlet, and inlet X-rays; **m**, **n. o**: 10ws post-op, removed the external fixation system; **p**, **q**, **r**: 2ys post-injury final follow-up

Table 3 Analysis of factors associated with Cole grading after surgery for unstable pelvic fractures

Projects	Cole rating	
	***R* value**	***P* value**
Months of age (m)	0.497	0.001**
Male/Female	-0.117	0.444
Height (cm)	0.119	0.437
Weight (kg)	0.138	0.366
BMI ($kg \cdot m^{-2}$)	0.054	0.726
Cause of injury	-0.268	0.075*
Associated injuries	0.305	0.042*
STAMP score	-0.068	0.658
ASA level	0.249	0.100
Operation time (min)	0.143	0.348
Intraoperative blood loss (ml)	-0.002	0.992
Tile classification (B\C)	0.533	< 0.001**
Tile classification (subtype)	0.237	0.117
Y cartilage closure	0.478	0.001*
Risser sign	0.305	0.042*
Post-op		
Pelvic asymmetry	0.276	0.067*
Pelvic deformity index	0.282	0.060*
Displacement value (mm)	0.319	0.032*
Post-op		
Matta reduction radiographic criteria	0.579	< 0.001**
Pelvic asymmetry	0.446	0.012*
Pelvic deformity index	0.356	0.016*
Displacement value (mm)	0.672	< 0.001**
Hospital days	0.239	0.180
Complications	0.207	0.172
Fracture healing time (w)	-0.054	0.723
Final follow-up WeeFIM scores	0.453	0.002*

BMI = body mass index; ASA = American Society of Anaesthesiologists; STAMP = Screening Tool for Assessment of Malnutrition in Paediatrics; WeeFIM = Functional Independence Measure scores

* Moderately relevant

** Strong relevant

following factors: patient age (in months), cause of injury, presence of associated injuries, surgery duration, pelvic fracture Tile classification (B/C), status of triradiate cartilage closure, Risser sign, preoperative and immediate postoperative pelvic asymmetry, preoperative and immediate postoperative pelvic deformity index, preoperative and immediate postoperative displacement values, immediate postoperative Matta pelvic reduction radiographic criteria, and final follow-up WeeFIM score (Table 3).

The variables showing correlation in univariate analysis were included in a multiple linear regression model. Factors such as triradiate cartilage closure status, Risser sign, preoperative displacement values, preoperative and immediate postoperative pelvic asymmetry, preoperative and immediate postoperative pelvic deformity index, and immediate postoperative Matta pelvic reduction radiographic criteria were excluded due to multicollinearity.

Table 4 Multiple linear regression analysis results of post-op Cole rating for unstable pelvic fractures

Projects	Colerating	
	Unstandardized coefficient	***P* Value**
Months of age (m)	0.012	< 0.001
Tile classification (B\C)	0.571	< 0.001
Post-op displacement value (mm)	0.038	< 0.001

Table 5 Comparison of perioperative indicators between the two patient groups

Projects	Group A	Group B	χ^2 Value	*P* Value
Number of cases	80	16		
Age (y)			5.722	0.027
≥ 13	17	8		
< 13	63	8		
Tile classification			7.011	0.012
B	44	3		
C	36	13		
Post-op displacement value (mm)			6.969	0.017
≥ 8	9	6		
< 8	71	10		

The analysis revealed that age (in months), pelvic fracture Tile classification (B/C), and immediate postoperative displacement values were independent predictors affecting the Cole pelvic fracture functional rating in children treated with external fixation for unstable pelvic fractures (Table 4). This regression model was statistically significant ($F = 21.861$, $P < 0.001$, adjusted $R^2 = 0.62$).

Determination of thresholds for poor prognosis in unstable pelvic fracturess

According to the Cole pelvic fracture functional rating criteria, ratings of excellent and good indicate acceptable pelvic function, while ratings of fair and poor indicate some degree of pelvic functional impairment. Therefore, this study divided patients into Group A (excellent and good) and Group B (fair and poor) based on their Cole ratings. Differences in age, Tile classification, and immediate postoperative displacement values between the two groups were analyzed to determine the thresholds, such as age increasing incrementally by 1 year (2, 3, 4 years, etc.), and χ^2 tests were used to compare the P-values between the two groups until $P < 0.05$ was reached (Table 5).

Discussion

Pelvic fractures are a type of fracture in trauma orthopedics with a high mortality rate and surgical complexity. While diagnostic and treatment strategies have been established for adults, there are significant differences in incidence, treatment, and prognosis for pediatric pelvic

fractures compared to adults. Pediatric pelvic fractures are less frequent and primarily involve closed injuries [15]. Children's pelvises are more elastic and flexible, with a higher proportion of cartilage and porous cortical bone, and their pubic symphysis and sacroiliac joints have greater elasticity. As a result, most pediatric pelvic fractures do not affect pelvic ring stability and conservative treatment is often effective [5]. However, as understanding of children's anatomical structure and growth development deepens, some scholars believe that certain unstable pelvic fractures in pediatric patients have insufficient bone remodeling capacity to correct displacement and deformities, leading to an increasing number of reports on surgical treatment for pediatric unstable pelvic fractures.

Currently, open reduction and internal fixation (ORIF) are commonly used for treating adult pelvic fractures, but there is no unified standard for reduction and fixation in children [8, 16, 17]. Children have smaller pelvic volumes and lower surgical tolerance, making ORIF less feasible [17]. External fixation has advantages such as simplicity, effectiveness in stabilizing the pelvis, controlling displacement, and reducing bleeding. In children with both horizontal and vertical instability, postoperative limb traction can achieve similar fixation results to ORIF, making external fixation increasingly accepted by pediatric orthopedic surgeons [11, 18]. However, as the number of treated cases and experience have increased at our institution, some pediatric patients treated with external fixation still have poor prognoses. Given the limited research on the surgical treatment and prognosis of pediatric pelvic fractures, we conducted a retrospective analysis of 96 children with unstable pelvic fractures treated with external fixation to explore risk factors affecting prognosis. We found that most pediatric patients with unstable pelvic fractures had good outcomes with external fixation, but patients aged ≥ 13 years, with Tile type C fractures, and immediate postoperative displacement ≥ 8 mm had poorer Cole ratings. This study is the first to explore independent predictors of prognosis in children with unstable pelvic fractures treated with external fixation, providing reference for clinical treatment planning.

Age is a significant factor in predicting the impact of treatment on the prognosis of pediatric pelvic fracture patients. Previous academic opinions suggested that immature children's pelvic fractures can reshape after healing with conservative treatment but reports of poor outcomes with conservative treatment are increasing. Pascarella et al. [19] and Amorosa et al. [7] argued that pediatric unstable or displaced pelvic fractures require surgical treatment similar to adults, rather than relying on children's remodeling capabilities. However, ORIF is associated with significant trauma, bleeding, and wide dissection, making it intolerable for some young children. Tile et al. [20] and Nierenberg et al. [21] believed that uncomplicated pelvic fractures do not require surgery, but conservative treatment of unstable pelvic fractures has severe long-term complications [22]. Kenawey et al. [11] recommended external fixation for pediatric unstable pelvic fractures, but it has poor posterior ring fixation stability in older children. These scholars did not consider patient age in their evaluations. Given the significant differences in skeletal maturity across two growth peaks in children, the treatment and prognosis of pelvic fractures are decisively influenced, making it impractical to use a single treatment approach for all age groups. We found that children under 13 years old with unstable pelvic fractures had satisfactory outcomes with external fixation, but older children may need ORIF similar to adults. Although triradiate cartilage closure status and Risser sign were excluded due to multicollinearity with age, univariate analysis showed their correlation with long-term Cole scores. Therefore, we suggest that patients under 13 years old with incomplete triradiate cartilage closure and Risser sign ≤ 4 should be treated with simple and convenient external fixation, while others may require ORIF.

Currently, there is no widely accepted or ideal classification system specifically designed for pediatric pelvic fractures. The Torode-Zieg classification, with its Type I, II, and III representing stable fractures, provides limited surgical guidance for Type IV, which involves unstable fractures. The Young-Burgess classification lacks a prognostic evaluation, and although the Tile classification plays a crucial role in guiding the surgical management and prognosis of adult pelvic fractures, its application in children faces challenges, particularly regarding treatment options [8, 23, 24]. Therefore, there is currently no classification system that is directly applicable to pediatric pelvic fractures. In this study, we applied the Tile classification to more thoroughly differentiate between horizontal and vertical instability in pediatric pelvic fractures. Our findings indicate that, similar to adults, children with Tile C fractures tend to have poorer long-term Cole scores. This may be attributed to greater displacement, reduced pelvic stability, and suboptimal vertical stability outcomes from limb traction [22, 24, 25]. However, statistical analysis did not reveal a significant correlation between the Tile subtypes and prognosis, suggesting that more cases are needed to support subgroup analysis. Furthermore, some patients with Tile B fractures also had less favorable long-term Cole scores. The pediatric pelvis, often likened to an "energy-absorbing box," benefits from a strong periosteum, ligaments, and flexible pubic symphysis and sacroiliac joints, which allow for deformation without fracture. Pediatric pelvic fractures can absorb more energy compared to adults, suggesting that treatment plans should integrate both

the classification system and the age-related characteristics of the patient. This highlights the need for a more nuanced approach to pediatric pelvic fracture management, accounting for both mechanical and biological differences between children and adults [25].

External fixation combined with limb traction typically yields good outcomes for pediatric pelvic fractures, but poor outcomes may occur if vertical instability involves the posterior pelvic ring. Matta's radiographic criteria for pelvic reduction is an important indicator for assessing posterior ring stability post-surgery in adults, so we used it to evaluate immediate postoperative displacement [25]. The criteria categorize reduction quality as excellent (< 4 mm), good (4–10 mm), fair (10–20 mm), and poor (> 20 mm), with excellent and good typically having fewer long-term complications. Including Matta criteria and immediate postoperative displacement in the model revealed collinearity, with displacement being the more fundamental indicator. Our results showed that immediate postoperative displacement ≥ 8 mm predicted poorer outcomes, suggesting that patients with significant vertical displacement may need posterior structure surgery for better long-term pelvic function [26]. Notably, superficial pin track infections are unavoidable with external fixation but are controllable with disinfection and dressing changes, and we did not encounter lateral femoral cutaneous nerve injury reported in literature.

Limitations

Our study still has some limitations: small sample sizes for some Tile subtypes prevented subgroup analysis after regression, short follow-up time may improve outcomes for some poor prognosis patients as they continue to grow, and some patient evaluations by guardians may introduce placebo effects and minor biases.

Conclusions

This study investigated prognostic factors for pediatric unstable pelvic fractures treated with external fixation. The analysis revealed that age, Tile classification, and immediate postoperative displacement are independent predictors of prognosis. Children aged ≥ 13 years, with Tile type C fractures, and immediate postoperative displacement ≥ 8 mm had poorer outcomes. External fixation combined with postoperative limb traction is highly effective for children under 13 with immature skeletons. However, older children or those with the aforementioned high-risk factors may require ORIF similar to adults. These findings provide important reference points for pediatric orthopedic surgeons in selecting treatment plans, thereby improving the treatment outcomes and long-term prognosis for children with unstable pelvic fractures.

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Author contributions
HZ and RZ: conceptualization, writing–original draft, writing–review and editing, patient management and literature review; QW and DZ: supervision, editing of the manuscript, critical appraisal, and final approval of the manuscript; WF and BS: writing–review and editing, patient management, and literature review All authors contributed to the article and approved the submitted version.

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Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This retrospective study was approved by the ethics committee of Beijing Children's Hospital, Capital Medical University, National Center for Children's Health (Code: [2024]-E-118-R). All methods were carried out in accordance with relevant guidelines and regulations. And informed consent was obtained from all subjects and/or their legal guardians.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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