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Functional outcome of pelvic fractures in children: does age affect outcome?

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Objective
The objective of this study was to assess the early radiological and functional outcome of either conservatively or surgically treated pediatric pelvic fractures.
Patients and methods
This was a prospective study of pediatric patients with pelvic fractures resulting from high-energy trauma. Management was either conservative or surgical. Score-based functional outcome assessment was done.
Results
A total of 30 patients were enrolled in the study. Of them, 20 patients were managed conservatively and 10 patients were surgically treated. We had three mortality cases. The mean follow-up period was 9 months. Functional outcome score was 74 for conservative and 70 after operative treatment according to Majeed score. Limb-length discrepancy, back pain, skin macerations, infection, and nerve injury were the encountered complications.
Conclusion
Pediatric pelvic fractures classified as Tile A or B can be successfully managed conservatively. All vertically unstable fractures should be reduced and fixed as the pediatric pelvis has a very limited remodeling power for this type of fracture.

Keywords:
pediatric fractures, pediatric pelvic fractures, pelvic fracture, pelvic fracture in children, pelvis

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Introduction

Trauma is the leading cause of death and disability in children. Pelvic fractures, although rare, with a reported incidence of one per 100 000 children per year, are associated with high mortality rates (up to 25%), and are second only to skull fractures for morbidity [1,2]. Fractures of the pelvis in adults are well documented in the literature; in contrast, there are relatively few reports on fractures of the pediatric pelvis. A pediatric pelvic fracture represents a reliable marker of multisystem trauma. The greater cartilaginous volume and bony plasticity of the pediatric pelvis provide an increased capacity for energy absorption before fracture. As a result of these anatomical differences, a pelvic fracture in a child demands a comprehensive, multisystem approach [3,4].

The treatment recommendations for pediatric pelvic fractures have undergone certain changes during the last decade. Historically, these fractures were managed nonoperatively with bed rest, traction, pelvic slings, or hip spica casts. The rationale for this approach being high union rates, extensive remodeling capacity, favorable results, and minimizing the risk of triradiate cartilage injury [5,6]. Long-term follow-up studies have however reported significant residual morbidity, primarily owing to low back pain and leg-length discrepancies [7,8].

In this study, we assessed the functional outcome and degree of disability or handicapping left after healing of the pediatric pelvic fracture treated either conservatively or surgically. The ethical committee of Cairo University approved the study.

Patients and methods

During the period between January 2010 and January 2012, we conducted a study to assess the functional outcome of pelvic fractures in children younger than 15 years of age managed conservatively or operatively. A total of 30 patients were enrolled in the study (18 males and 12 females), with mean age 7.2 years (1.5–15 years old). All the cases had high-energy trauma. Overall, 15 patients were involved in pedestrian accidents (most common), nine patients were involved in motor vehicle accidents, three patients had crushing injuries, and three patients fell from height.

All patients had an anteroposterior radiograph of the pelvis showing both hips (pelvis anteroposterior). After

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verifying the vital stability, most of the patients were subjected to inlet/outlet views and computed tomography scanning of the pelvis. In three patients, only the anteroposterior radiograph of the pelvis was the one available as they were vitally unstable and we had to rush them into the operating room (OR).

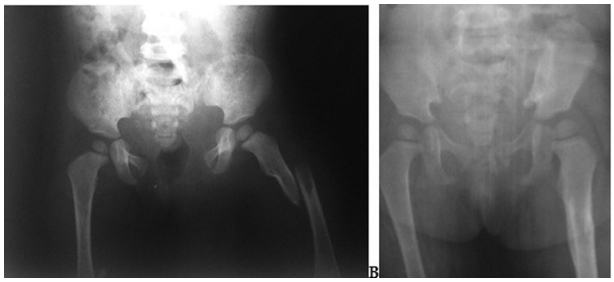
According to Tile classification [9], there were three cases of type A, 21 cases of type B, and six cases of type C. According to Torode and Zeig classification [10], 28 cases were type 4 injuries.

Associated injuries were as follows: one (3.3%) brain concussion, one hemothorax, one pneumothorax (6.7% chest injuries), two splenic tears, one renal tear, two abdominal collections (16.7% abdominal), one bladder tear, two urethral tear, one vaginal tear, and one Morel-Lavallée lesion (subcutaneous serosanguinous collection over the hip and flank area) over the sacral area which needed evacuation by a small incision and ~500 ml of blood was drained. Regarding associated orthopedic injuries (43.3%), there were 10 lower limb fractures (tibia, femur, and neck of femur), one acetabular fracture, one traumatic above knee amputation, and two upper limb fractures.

Conservative or nonoperative treatment was adopted in closed fractures and vitally stable patients at presentation in whom adequate and accepted reduction could be achieved without the need for operative intervention. It was in the form of bed rest in eight cases and spica cast in 12 cases (Fig. 1).

A total of 10 patients were treated surgically. Indications were open fractures or hemodynamic instability necessitating the use of external fixator as a resuscitative method. Methods of fixation used were external fixator (seven cases), iliosacral screws (two cases), and plates and screws (two cases). The patients who were treated in our study did not require any special rehabilitation program at the end of treatment.

Figure 1



A 1.5-year-old female patient was involved in a car accident, with open book fracture pelvis (Tile B1) with left subtrochanteric fracture femur; closed reduction under general anesthesia in a spica cast was done. (a) Radiograph of the pelvis anteroposterior with proximal femoral fracture on admission. (b) Follow-up radiograph at 3 months with Majeed score of 65.

For radiological outcome assessment, four criteria were evaluated in our patients' radiographs: posterior displacement, vertical displacement, pubic symphyseal translation, and sagittal rotation. Matta and Tornetta [11] graded the results according to the amount of displacement as follows: excellent (≤4 mm), good (4–10 mm), fair (10–20 mm), and poor (>20 mm).

Functional outcome assessment was done using a scoring system we made inspired from Majeed scoring system Table 1 [12]. It includes 30 points for pain, 10 points for sitting, and 36 points for gait assessment, with a total out of 76. The patients were scored after 3, 6 months, and every 6 months after injury.

Results

After exclusion of the mortality cases, 27 patients had been followed up for a mean of 9 months ranging from 6 to 24 months.

At the first 3 months of follow-up, the mean total score was 60. All the patients had problems with walking and standing, varying from inability to walk unaided to walking a distance then pain sets in. A total of four patients complained of unintended external rotation of the affected limb during walking especially when they try to run. Most patients had good satisfactory function regarding daily activities except for the residual limp (increases with attempt at running) that varied between patients but was getting prominent as the patient's age increased. At the 6 months visit, the mean total score was 73; most of the patients showed improvement regarding walking. Most of the patients were satisfied, and there was no need for further follow-up.

Regarding complications, we had three patients with limb-length discrepancy: two were less than 1 cm and one had significant at 5 cm, for which we did femoral lengthening 2 years later. Two patients experienced residual low back pain, two experienced skin macerations from the cast, two pin tract infections, one wound infection, and one case of postoperative foot drop.

Radiologically, residual displacement of the fractures and grading of our cases is stated in Table 2. More than

Table 1 Majeed score for grading of outcome of pelvic fractures

Questions and possible answers	Number of points
Pain – 30 points	
Intense, continuous at rest	0–5
Intense with activity	10
Tolerable but limits activity	15
With moderate activity, abolished at rest	20
Mild, intermittent, normal activity	25
Slight, occasional, or no pain	30
Work – 20 points	
No regular job	0–4
Light work	8
Change of job	12
Same job, reduced performance	16
Same job, same performance	20
Sitting – 10 points	
Painful	0–4
Painful if prolonged or awkward	6
Uncomfortable	8
Free	10
Sexual intercourse – 4 points	
Painful (or if man erection not possible)	0–1
Painful if prolonged or awkward	2
Uncomfortable, different from before	3
No complaints	4
Standing – 36 points	
Walking aids (11)	
Bedridden or almost	0–2
Wheelchair	4
Two crutches	6
Two sticks	8
One stick	10
No sticks	12
Gait unaided (11)	
Cannot walk or almost	0–2
Shuffling small steps	4
Gross limp	6
Moderate limp	8
Slight limp	10
Normal	12
Walking distance (11)	
Bed ridden or few meters	0–2
Very limited time and distance	4
Limited with sticks, difficult without, prolonged standing possible	6
One hour with a stick, limited without	8
One hour without sticks, slight pain or limp	10
Normal for age and general condition	12
Total	100

two-thirds of the patients graded as excellent were of the conservatively treated group.

The three patients with limb-length discrepancy had radiological malunion. Despite the presence of radiological malunion (within the 'fair' grade of Matta and Tornetta grading), patients were still satisfied functionally at 6 months.

Table 2 Radiological outcome grading using Matta and Tornetta [11] grading system (total is 29 as there was one patient who died on table)

Grades	Number of patients	Conservatively treated (mean follow-up 8.1 months)	Surgically treated (mean follow-up 11.6 months)
Excellent	16	12	4
Good	9	5	4
Fair	3	3	–
Poor	1	–	1

None of our patients experienced implant failure or thromboembolic complications. All the patients had evidence of union by 3 months and almost complete union after 6 months.

The three mortalities in our series were as follows: (a) a 3-year-old male child was run over by a car, had 7-cm sacroiliac diastasis, was vitally unstable on admission, and died of hypovolemic shock. (b) A 6-year-old girl with open Tile B1 fracture for whom an external fixator was done. She died after a few days of sepsis (Fig. 2). (c) A 10-year-old boy was run over by a truck and had massively crushed hemipelvis and external iliac complete maceration, for whom fixation and vascular grafting were done. He died after 2 days with multiple organ failure.

The mean age for the patients who were treated conservatively was lower than those treated surgically (6 years 3 months compared with 9 years 2 months).

The average functional score at 6 months of follow-up was 74 in patients treated conservatively and 70 in patients treated surgically. This difference was statistically significant (P=0.027).

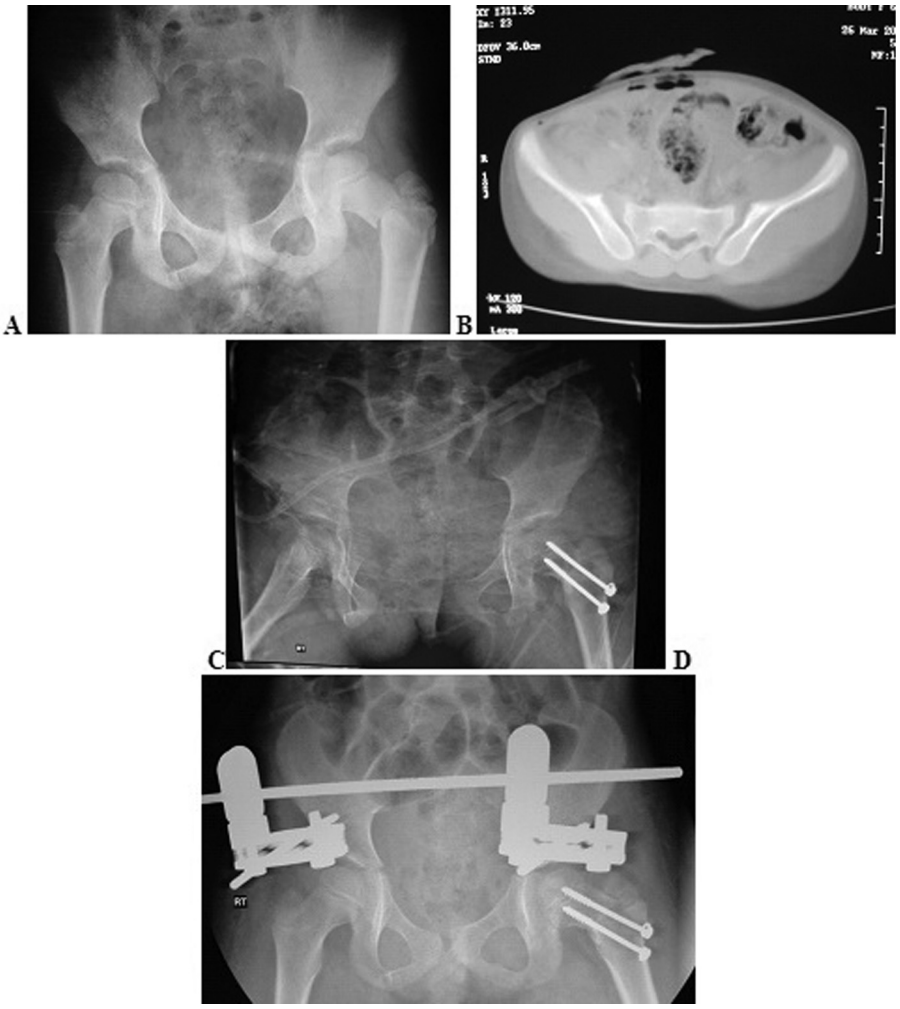
Most of the surgically treated patients presented with shock, which indicates the aggressiveness of the trauma and hence the need for intervention.

The relationship between the functional score at 6 months and the age whether younger or older than 7 years showed that there was statistically significant difference (P=0.031), with higher functional score in patients younger than 7 years.

Discussion

Most of the literature shows that the preferred modality of treatment of pelvic fracture in the pediatric population is the conservative one and that operative management has a very limited role because of the remodeling and healing power in this age group [5,6,13]. This concept was adopted by these studies

Figure 2



A 6-year-old female patient was involved in a road traffic accident, with bilateral sacroiliac anterior diastasis and very minimal symphyseal diastasis (open injury with vaginal tears) and left femoral neck fracture (a, b). Femoral neck fracture was fixed, and the obstetrics/gynecology specialists repaired vaginal tears with the patient in lithotomy position. Immediate postoperative radiograph (c) showed marked symphyseal diastasis for which we reoperated and fixed it with external fixator (d). This patient died on the seventh postoperative day of sepsis.

with relatively good results, but recently this concept is changing because of the better understanding of the fracture patterns and the need for a method to avoid major significant complications that may leave long-lasting disability especially in children close to maturity.

In our series, we were not able to evaluate delayed sequel because the duration of follow-up is relatively short; however, most of our patients were united in less than 3 months.

All injuries were high-energy events, with pedestrian accidents as the most common mechanism, which agrees with other published studies [13–15]. The number of cases encountered in the time interval of our study reflects a relatively high incidence of pediatric pelvic fractures encountered in our hospital (which is one of the biggest hospitals in Egypt and the Middle East). This may reflect the relatively less secure traffic for children in our country.

Regarding the fracture type, Leonard *et al.* [14] reported in their series that most children (18/39) sustained a Torode and Zeig type 3 fracture, which is a simple ring fracture, and 13 children sustained a type 4 ring disruption fracture. Subasi *et al.* [13] reported that according to Tile classification, 34 of the 58 fractures were type B and 24 were type C. Signorino *et al.* [16] reported that among the 20 patients evaluated, 15 of the fractures were not displaced or separated. In comparison with Signorino *et al.* [16] and Leonard *et al.* [14], our series had more unstable pelvic fractures, which may demonstrates the aggressiveness of the fractures we encountered in general.

Regarding associated injuries, our series supports the studies by Leonard *et al.* [14]. Banerjee *et al.* [15] and

Table 3 Comparing different published series with our series

References	Country	Period (years)	Type of study	Number of patients	Surgical	Clinical outcome	Mortalities
Leonard *et al*. [14]	Ireland	14	Retrospective	39	1	8 complicated cases: LLD, limp, incontinence	1
Banerjee *et al*. [15]	UK	10	Retrospective	44	1	1: secondary hip arthritis	7
Signorino *et al*. [16]	USA	20	Prospective	20	1	–	–
Chai *et al*. [17]	Australia	17	Retrospective	120	7	–	5
Subasi *et al*. [13]	Turkey	16	Retrospective	58	0	10: gait abnormalities and LLD	3
Grisoni *et al*. [18]	USA	6	Retrospective	57	–	–	–
This study	Egypt	2	Prospective	30	10	6: LLD, low back pain, foot drop. Mean score was 73/76	3

Chai *et al.* [17] that associated orthopedic injuries were common (43.3% in our series), but we had only one brain concussion in our series, which is against Leonard *et al.* [14] (25% of associated head injuries) and Chai *et al.* [17] (44%).

Regarding mortalities, we had three cases in our series (10%); all were victims of pedestrian run-over car accidents with aggressive injuries including symphyseal diastasis about 9 cm in one, sacroiliac (SI) diastasis about 10 cm in another, and rupture urethra and retroperitoneal hematoma in the last one. Our mortalities percentage lies within other studies percentage range with Leonard *et al.* [14] having 2.5%, Subasi *et al.* [13] 5%, and Banerjee *et al.* [15] 15.9%.

Regarding life-threatening hemorrhage from the pelvic fracture, we found it less common in children compared with adults. In our series, hemorrhage leading to shock happened only in one patient. This finding agrees with many authors [4,5,18]. As stated by previous authors, the lower incidence of vascular disruption in children may be because of the vasoactive properties of their blood vessels (particularly the arteries which undergo vasoconstriction as opposed to the more friable atherosclerotic adult vessels). Hence, by reducing the rate of hemorrhage, coagulation factors are not overconsumed, and life-threatening coagulopathy is avoided [5,19].

More than two-thirds of our patients had excellent radiological outcome. They were of the conservatively treated group, and this can be explained by the fact that most of these patients had minimal displacement compared with those treated surgically who had more displacement that required surgery.

The treatment recommendations for pediatric pelvic fractures have undergone certain changes during the last decade. Historically, these fractures were managed nonoperatively with bed rest, traction, pelvic slings, or hip spica casts. The rationale for this approach was the presence of high union rates, extensive remodeling capacity, and favorable results and to minimize the risk of triradiate cartilage injury [8,9]. However, long-term follow-up studies have reported significant residual morbidity such as low back pain and limb-length discrepancy [7,8].

Oransky *et al.* [20] reported eight unstable fracture patients who were managed surgically with plates and screws. He was the first to describe injury of the Risser's growth nuclei. This injury can partially explain the pathogenesis of iliac wing undergrowth that occurred in three patients of their series. They recommended that surgical treatment in displaced vertical fracture in children is mandatory as it is in adults and anatomical reduction of the fracture should be considered. Implants should be removed in all patients between 3 and 4 months after surgery to prevent growth arrest [20].

We agree with Leonard *et al.* [14], Banerjee *et al.* [15], and Subasi *et al.* [13] (Table 2) that most of the patients will be treated conservatively. Moreover, we agree on the importance of the anatomical reduction of vertically unstable pelvic fractures [20].

The mean age for the patients who were treated conservatively was lower than those treated surgically (6 years 3 months compared with 9 years 2 months) which can be attributed to the relatively accepted reduction of the fracture in younger age groups compared with older ones whom should be treated as adults as usually conservative management fails to achieve good results in this age group; hence, we concluded that better outcome is expected with younger patients.

We cannot conclude from these results that conservative management is better than the surgical one, as most of the conservatively treated patients had less severe trauma and lower incidence of associated

injuries and hence less aggressive mode of management was chosen for them.

We agree with Leonard *et al.* [14], Banerjee *et al.* [15], and Subasi *et al.* [13] (Table 2) that patients who developed complications mostly were because of vertically unstable pelvic fractures. We used the Majeed scoring system for functional outcome assessment because it is specific for pelvic fractures which gave us solid objective data, and it was not done by any of the studies we are comparing with except Signorino *et al.* [16] who used the more general WeeFIM instrument (formerly known as the Functional Independence Measure for Children) which assesses self-care, mobility, and cognition.

Weakness of our study is the short-term follow-up. Longer-term follow-up period is needed to assess certain complications encountered in other studies like secondary scoliosis and growth affection (Table 3).

Conclusion

Our results indicate that pediatric pelvic fractures are not uncommon in our society with road traffic accidents being the most common mechanism of injury. They are also characterized by the high incidence of associated injuries, which should be looked for thoroughly immediately after pediatric pelvic fracture is diagnosed. Initial treatment goals are to indentify life-threatening injuries and to control hemorrhage. Pediatric pelvic fractures classified as Tile A or B can be successfully managed conservatively through spica casting as long as good reduction is achieved with the fact that patient satisfaction is usually better than the radiological sacroiliac joint persistent gap or delayed union. Vertically unstable fractures can lead to Leg Length Discrepancy (LLD) and delayed sequel unless treated by open reduction internal fixation (ORIF) and accurate reduction.

Generally, when fair reduction is achieved and maintained with suitable treatment choice in the pediatric population, the child obtains good functional outcome by 6 months specially those who are younger than 7 years. Long-term follow-up is needed to assess affection on growth, sacroiliac joint ankylosis and low back compensations like scoliosis beside the functional outcome.

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Conflicts of interest
There are no conflicts of interest.

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