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Original Article

IS POSTERIOR-ONLY RIGID FIXATION AN EFFICIENT OPTION FOR THE TREATMENT OF UNSTABLE LATERAL COMPRESSION PEDIATRIC PELVIC FRACTURES?

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Abstract

Background: *Pediatric pelvic fractures (PPF) are rare injuries and usually resulted from high-energy mechanisms. Unstable lateral compression fractures may leave permanent deformity with pelvic asymmetry. The purpose of this study was to evaluate the safety and efficacy of rigid posterior fixation for treatment of unstable lateral compression pelvic fractures in children.* ***Methods:*** *A retrospective case series of 13 patients with unstable lateral compression pelvic fractures. All cases were treated in a university hospital between January 2013 and May 2020. Inclusion criteria were: all patients under 16 years old, hemodynamically stable and who were treated posteriorly using rigid posterior fixation with a minimum follow-up of 12 months. Assessment was done clinically utilizing Majeed score and radiologically utilizing Matta score.* ***Results:*** *There were 8 boys and 5 girls with a mean age of 9.5 ± 4 years. There were 8 children with an immature pelvis. The most common causes of injury were motor car accident (61.5%). The interval from injury to surgery was 2-11 days with a mean of 6 ± 2 days. The mean intraoperative time was 81.9 ± 18.3 minutes with a mean operative blood loss of 113.9 ± 48 ml. According to the Matta and Tornetta score; the reduction was rated excellent in 10 patients and good in 3 patients. According to the Majeed score, the outcome was rated excellent in 11 patients and good in 2 patients.* ***Conclusion:*** *Posterior-only rigid fixation by interfragmentary intrailiac screws and plates is a safe and effective method for treatment of unstable lateral compression fractures in children.*

Keywords: *Pediatric pelvic fractures, Lateral compression fractures, Crescent fractures, Posterior-only fixation, Interfragmentary intrailiac srews.*

1. Introduction

Pediatric pelvic fractures are rare injuries accounting for 0.2% of all pediatric fractures [1,2]. The pediatric pelvis has an inherent flexibility, and need higher forces to deform the pelvic ring. Besides, it has multiple weak points due to presence of growth plates all around the pelvis, through which fractures can dissipate [3, 4]. As a general rule, if there is a superior or anteroposterior displacement of the hemipelvis of one cm or more, the pelvis is considered unstable [5,6]. Unstable pediatric pelvic fractures are classified as Modified Torode and Zieg (MTZ) type IV or Tile types B and C [7-9]. Lateral compression (LC) injuries to the iliac wing result in crescent fractures [10,11], that leave the hemipelvis unstable rotationally [10]. However, about 13% of crestent fractures can be vertically unstable [12,13].

Displacement and asymmetry of the pelvic ring will not remodel and cannot be treated uniformly by conservative methods [14,15]. Persistent pelvic asymmetrycan lead to irreversible consequences including: disturbed gait, chronic sacoiliitis and pelvic floor incomptency. Crescent fractures are considered one of absolute indications for surgical treatment [16]. In surgical treatment of unstable lateral compression pediatric pelvic fractures, posterior reduction and fixation is preferred whenever possible. Using posterior extra-pelvic approach can facilitate reduction and prevent iatrogenic neurological injury. However, anterior sacroiliac approach is preferred when there is an associated acetabular fracture. We hypothesized that posterior rigid anatomical fixation by interfragmentary intrailiac srews combined with plating would be sufficient enough to maintain the stability and reduction of pelvic ring in unstable lateral compression pediatric pelvic fractures.

2. Patients and Methods

2.1. *Study design*

A retrospective case series study of 13 patients with unstable lateral compression pediatric pelvic fractures was carried out. All cases were operated by the same surgeon between January 2013 to May 2020 in orthopedic surgery department of Suez Canal University Hospitals. Data was retrieved from the hospital information registry system. An institutional research board approval was obtained.

2.2. *Patient selection*

All patients under the age of 16 years, hemodynamically stable, treated posteriorly using interfragmentry intrailiac screws with augmenting plate and have a minimum follow-up of 12 months, were included in our study. Patients who had major anterior ring displacement of more than 2.5 cm, unfit for surgery, those with firearm injuries or with associated acetabular fractures were excluded. Based on preoperative Plain X-ray (AP view, inlet and outlet views and computed tomography (CT) scans with three-dimensional (3D), diagnosis and classification were confirmed, fig. (1-a & b).

Figure (1) **a.** Anterior view 3D CT of growing pelvis shows: displaced posterior crescent fracture and anterior rami fracture of right hemipelvis, **b.** Posterolateral view 3D CT of growing pelvis shows: posterior crescent fracture.

2.3. *Surgical technique*

All surgeries were operated by the same surgical team. Under general anesthesia, all patients were positioned prone on a radiolucent table. Preparation of surgical field and intraoperative fluoroscopy was done. A posterior paramedian incision, started 2-4cm distal to the posterior superior iliac spine (PSIS) and curved along the iliac apophysis was used. Dissecting posterior portion of the gluteal muscles from posterior iliac wing and the sacrum to expose fracture site and allow direct reduction of the iliac fracture and indirect reduction of the SIJ. Fracture was manipulated, fig. (2) and reduced using farabeuf clamp. The apophysis was reduced and reattached to the bony crest with sutures. Reduction was confirmed by palpation of the anterior aspect of the SIJ through the greater sciatic notch, and by intraoperative fluoroscopic imaging.

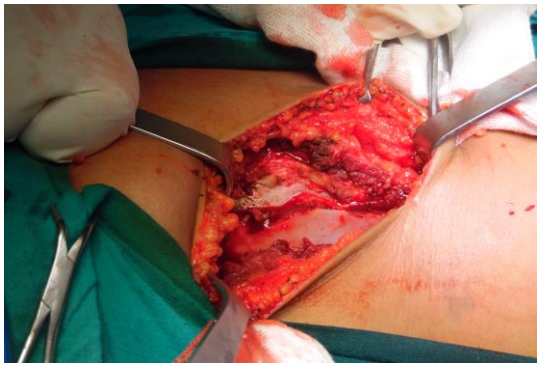

Figure (2) Fracture site after elevation of gluteus muscle.

Primary fixation by 3 interfagmentary intrailiac k-wires and confirmation by C arm fluoroscopy were done. Defenitive interfragmentry fixation by 2 cannulated screws with washers (6.5mm if older than 11 years or 4mm in younger children) of appropriate length was done, fig. (3).

Figure (3) Fixation of fracture by 6.5 mm intrailiac interfragmentary screw.

Intraoperative anteroposterior image view (AP) accurately reflects the distance from the intrailiac screw to the sciatic notch. The obturator oblique view accurately reflected that the screw trajectory was located in the cancellous bone corridor between the inner and outer tables of the ilium superior to the acetabular dome from the PSIS to the anterior inferior iliac spine (AIIS) with the other screw being inferior to the first one. A small DCP plate (4-6 holes) was prepared and bent after using template, to be used as neutralizing plate on outer table of posterior ilium, fig. (4).

Figure (4) Fixation of fracture by 3.5 mm small DCP on outer iliac table.

Intraoperatively, provisional ring stability and acceptable reduction was checked. A relatively stable anterior ring was confirmed by fluoroscopy without any significantly displaced rami fractures or diastasis. Closure of wound in layers with suction drains were used.

2.4. *Postoperative care*

Postoperative plain x-rays were done to assess the quality of fracture reduction, fig. (5).

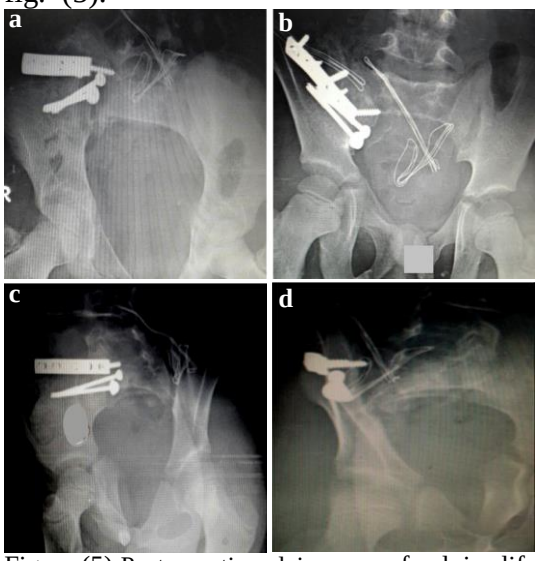

Figure (5) Postoperative plain x ray of pelvis, different views show fixation of fracture with reduction of pelvic ring by 2 intrailiac interfragmentry screws and augmenting outer table 3.5 mm small DC plate, **a.** inlet view, **b.** outletview, **c.** iliac view and **d.** obturator view.

All cases were assessed immediate postoperative, six weeks, and 12 weeks, 6 months and 12 months. Radiological outcomes were evaluated utilizing Matta and Tornetta score in which reductions were graded based on the largest displacement measured on the 3 views (excellent, 0-4 mm; good, 5-10 mm; fair, 11-20 mm; poor, >20 mm) and clinical outcomes were evaluated utilizing Majeed score. The postoperative rehabilitation protocol included restriction of toe-touch weight-bearing activity for 6-8 weeks then start full weight bearing was achieved at 8-10 weeks postoperatively. The final clinical evaluation was done using the Majeed's scoring system one year postoperatively.

2.5. *Statistical analysis and data management*

Data were collected throughout history, basic clinical examination, operative notes and radiological investigations. All data entry and analysis were accomplished using

base statistical program (spss 23) software for analysis, adopting in the outcome the following statistical test:

- Quantity variable was expressed as means and standard deviation
- Quality variable was expressed as frequency and percentage.
- Difference would be statistically significant if probability P-value < .05 using an appropriate statistical test.

3. Results

The mean age was 9.5 ± 3.9 years ranging (3 to 15). It incuded 8 boys (61.5%) The most common causes of injury were motor car accident (61.5%), fall from height (23.1 %) and run-over injuries (15.4%). There were eight children with an immature pelvis, their mean age of 7.13 ± 2.9 years ranging (2-11 years) in contrast to five children with mature pelvis, their mean age of 13.2 ± 1.3 years ranging (12-15 years). With respect to the pattern of the anterior pelvic injuries, the immature pelvis was more susceptible to symphyseal diastasis (n= 2, 25 %), whereas fractures of the pubic rami occurred more frequently in the adolescent group (n = 5, 100%). A total of 9 children (69.2%) sustained associated injuries in two or more separate regions. Seven children (53.8%) had an associated head injuries, five (38.5%) had abdominal injuries while three patients (23.1%) had chest injuries. In addition to their pelvic fractures, seven patients (53.8%) had extrapelvic fractures of extremities with two of them (28.6%) needed surgical intervention at our institution with no statistically significant difference between the immature and mature groups. The mean ISS (as calculated by our trauma registry) was 15.8 ± 5.5 (9 to 27) with seven children scored ≤ 16, tab. (1). A total of 5 patients (38.5%) were initially admitted to the intensive care unit (ICU).The mean time from injury to surgery was 6 ± 2 days ranging 2-11 days. Intraoperative time mean was 81.9 ± 18.3 minutes ranging (60- 130 minutes). Intraoperatively, the mean blood loss was 113.9 ± 48 ml (ranging from 50- 200 ml) with a strong positive correlation between age and intraoperative amount of blood loss (R= 0.78, p= 0.002). According to the Matta and Tornetta radiological evaluation criteria, the reduction was rated excellent in 10 patients (76.9%) and good in three patients (23.1%) with no statistically significant difference between the immature and mature groups. In addition, according to the Majeed functional evaluation at the final follow-up, the outcome was rated excellent in 11 patients (84.6%) and good in two patients (15.4%) with their mean score 89 ±5.4 ranging from (80 - 96) with no statistically significant difference between the immature and mature groups. The functional scores between children who were operated on within the 1st week and those who were operated on after one week, as their scores were 90.3 ± 4 and 84.6 ± 8.1 respectively. However, the difference was not statistically significant. Out of 13 children, only 1 case (7.7%) had deep wound infection with no other reported postoperative complications.

Table (1) The mean ISS as calculated by our trauma registry

Serial	Age	Sex	ISS	Day classification	Mechanism	ICU Admission	Head	Face	Visceral	Others	Chest	Abdomen	Extremities	Anterior	Loss	Interval	Operative time	Functional	Radiological
1,00	12,00	female	27,00	day II	MCA	yes	yes	no	yes	yes	no	yes	yes	ipsilateral pubic rami	100,00	11,00	90,00	80,00	good
2,00	15,00	male	9,00	day II	MCA	no	no	yes	no	no	no	no	no	ipsilateral pubic rami	150,00	3,00	130,00	85,00	good
3,00	3,00	female	18,00	day I	MCA	yes	yes	no	yes	no	no	no	no	contralateral pubic rami	75,00	9,00	75,00	94,00	excellent
4,00	8,00	male	13,00	day II	MCA	no	no	no	yes	no	yes	yes	no	symphsis pubis	80,00	4,00	85,00	92,00	excellent
5,00	7,00	male	18,00	day II	FFH	yes	yes	no	no	yes	no	no	yes	ipsilateral pubic rami	60,00	7,00	90,00	93,00	excellent
6,00	12,00	female	16,00	day III	MCA	no	no	no	no	no	no	no	yes	ipsilateral pubic rami	180,00	4,00	80,00	95,00	excellent
7,00	14,00	male	13,00	day III	run over	no	yes	no	yes	yes	no	yes	no	bilateral pubic rami	200,00	5,00	70,00	88,00	excellent
8,00	11,00	male	18,00	day II	MCA	no	no	no	no	yes	no	no	yes	ipsilateral pubic rami	110,00	7,00	70,00	92,00	excellent
9,00	10,00	female	9,00	day III	MCA	no	yes	no	no	no	no	no	no	ipsilateral pubic rami	170,00	2,00	70,00	96,00	excellent
10,00	13,00	male	22,00	day I	run over	yes	yes	no	yes	yes	no	yes	yes	bilateral pubic rami	120,00	10,00	60,00	80,00	good
11,00	5,00	female	13,00	day II	MCA	no	no	no	no	yes	yes	no	yes	symphsis pubis	75,00	6,00	65,00	85,00	excellent
12,00	9,00	male	9,00	day III	FFH	no	yes	no	no	yes	no	no	no	bilateral pubic rami	110,00	3,00	100,00	87,00	excellent
13,00	4,00	male	20,00	day II	FFH	yes	no	no	yes	no	no	yes	yes	ipsilateral pubic rami	50,00	7,00	80,00	90,00	excellent

4. Discussion

In the period between January 2013 and May 2020, 13 children with unstable lateral compression pelvic fractures were operated in our university hospital. There were eight children with an immature pelvis, the oldest was 11 years old while five

children were with mature pelvis, the oldest was 16 years old. There were eight boys (61.5%) and five girls (38.5%) with a mean age 9.5 years. The most common cause of injury was motor car accident (61.5%). In a retrospective comparative study by Hermans et al. [17], the median age of pediatric group was 11 years and 57% were boys. Compared with adults, children suffer more from MVAs and are less involved in falls from heights or crush injuries. Adults are often the drivers of a car, while children are usually struck by a car from the side whereby they sustain lateral compression type injuries [18]. Based on our data, associated injuries are most likely to occur in the extremities (53.8%) and head (53.8%), followed by the abdomen (38.5%)and chest(23.1%). Nine patients (69.2%) sustained associated injuries in two or more separate regions. These are comparable with Shaath's study [2] of associated injuries in children with pelvic fractures. Ismail et al. [19] in a National Pediatric Trauma Registry analysis of 722 pediatric pelvic fractures, reported an incidence of 11% of associated solid organ injuries. Bond et al., in a study of 54 pediatric pelvic fractures, reported an incidence of 20.4% of associated intra-abdominal injuries. In the Demetriades study [20], the incidence of associated abdominal injuries was 13.7% in children. Hermans et al. [17] demonstrated a total of 50% of the paediatric patients had injuries in more than two regions close to the pelvic fracture. Symphyseal disruptions were observed in 2 cases of young children with an immature pelvis (25%), whereas in the mature adolescent group the mode of failure tended towards fractures of the pubic rami (100%). This was agreed by Kenawey et al. [21] retrospective study. However, this contrasts with Silber and Flynn's [22] work, which described the opposite. In our study all cases were operated through posterior approach with indirect articular reduction and nearly anatomical fixation. This approach is associated with less complications. Borrelli et al. [23] used this approach in their study and reported that it had low morbidty rates and lower incidence of complications. The iliac apophysis was considered an obstacle that prevent fracture reduction, it had to be freed and reduced to its anatomical place in all cases. It also reduces the risk of growth complications. Oransky et al. [24] stated that anatomical reduction of injury to Risser's nucleus (the iliac apophysis) is essential to reduce the likelihood of growth arrest and the development of pelvic deformity. Also, another study reported that associated avulsion of the iliac crest apophysis was seen in eight of ten children in the immature group with a type C injury. The surgeon should anticipate this injury and be prepared to reduce and fix the iliac apophysis anatomically [21]. In our study, the mean operative time was 81.9 ± 18.3 minutes and the mean blood loss was 113.9 ml. This contrasts Shui et al. [25] study on adult patients which reported a mean operative time of 69 minutes for ORIF while the mean intraoperative and postoperative blood loss was186 ml. The controversies in blood loss are due to less blood volume in children. The reductions were rated radiographycally as excellent in 10 (76.9%) patients and good in 3 (23.1%) patients. In addition, functional evaluation at the final follow-up was rated excellent in 11 patients (84.6%) and good in 2 patients (15.4%) with their total scores ranging from (80 - 96; SD ± 5.4) with no statistically significant difference between the immature and mature groups. Another study on 30 adult patients with crescent pelvic fractures fixed by a single cannulated iliac screw combined with reconstruction plate fixation. The reduction was rated as excellent in 66.7% of patients and good in 33.3% of patients while the Majeed functional evaluation at the follow-up appointment was rated as excellent in 93.3% of patients and good in 6.7% of patients [26].

5. Strength and Limitations

To our knowledge, there are few studies

in literature that report unstable lateral compression pelvic fractures in skeletally immature patients. The main limitations of our study are the retrospective nature, the small number of cases, short term follow-up period, and further biomechanical tests must be implemented to verify the stability of this technique in children.

6. Conclusion

Posterior-only rigid fixation by interfragmentary intrailiac srews combined with plating, is a safe and effective method for treatment of unstable lateral compression fractures in children.

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