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ORIGINAL ARTICLE

Surgical Management of Fracture Pelvis in Skeletally Immature Patients

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ABSTRACT

Background: Despite pelvic fractures in pediatrics are rare, they are potentially life-threatening injuries and may cause significant long-term complications. There are many debates in the literature about the best method for management of fracture pelvis in skeletally immature patients**.** The aim of this paper is to assess both clinical and radiological outcomes after surgical procedures intervention for unstable displaced fracture pelvis in skeletally immature patients. **Methods:** The study included 24 skeletally immature patients under 16 years old years with minimum 4 and maximum 14 (Mean± SD) was 8.25±2.86. Regard sex distribution male were 16 patients (66.7%) and females were 8 patients (33.3%) .The most common trauma mechanism was pedestrian injury [11 cases=45.8%] followed by motor vehicle accident [7 cases=29.1%] then crush injury 3 cases=12.5%] and fall from height [3 cases=12.5%] .All patients are classified according to Tile classification were 18 patients having fracture pelvis Tile's type B [75%] and 6 having Tile's type C injuries [25%]. **Results:** The radiological union distribution among studied group was minimum 6 weeks and maximum 10 weeks (Mean± SD) was 6.95±1.04 .Majeed score distribution among studied group was significantly increased. Majeed score was at 3 months 63.0±5.56 at 6 months was 73.66 ± 3.42 and at last follow up 75.25±2.51 (P<0.001). Overall complication distribution among studied group occurred in 7 patients (29.2%). Two cases had wound dehiscence, 3 cases had pin track infection and 2 cases had neurological impairment. Complicated cases significantly longer in union and lower in Majeed score.
Conclusions: The surgical treatment for unstable pelvic fractures in skeletally immature patients gives us valuable results so we could recommend this option for management in these difficult cases to improve the long-term results.
Key words: Fracture Pelvis; Skeletally Immature; Patients

INTRODUCTION

Fractures of pelvis in skeletally immature patients are rare injuries with an incidence of 2% of all skeletally immature fractures; occur almost due to high energy trauma [1].This rare incidence in pediatrics is due to peculiar anatomy of pelvis consisting of greater percentage of cartilage and bony plasticity [2]. They are complicated with substantial morbidity and mortality [3]. Pelvic fracture due to high energy is associated with injuries to the head and intra-abdominal region and greater risk of hemorrhage so displaced pelvic fracture is a marker of severity of the trauma [4]. Mortality rate incidence after fracture of the pelvis in pediatric was of average 6.4% because of associated injuries [5].

The traditional method of treatment was non-operative whatever stability of pelvic ring or displacement amount [6]. However, further complications result from conservative management as low back pain, pelvic asymmetry, leg length inequality, spinal deformity and gait disturbance so to avoid this problems treatment in specialized hospital is needed to provide the optimum results [7]. The key for best management is to identify pattern and complexity of fracture [8].

Aiming to achieve anatomical reconstruction of the pelvic ring is the ultimate goal for unstable displaced fractures either by posterior or anterior or both fixations to avoid any residual displacement especially posterior displacement [4]. The type of implant choice is addressed according to several factors as patient age, fracture site and morphology [9]. The existing data in the literature is poor with deficient material due to small size studies [10].The aim of this paper is to assess both clinical and radiological outcomes after surgical procedures intervention for unstable displaced fracture pelvis in skeletally immature patients.

METHODS

In the period between January 2019 and December 2021, this prospective study was performed after a written informed consent was obtained from all participants; the study was approved by the research ethical committee of Faculty of Medicine, Zagazig University. The study was done according to The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans. Detailed data was given to patients and or their parents about management. Based on the advanced life support (ATLS) protocol was applied with use of pelvic binder in patients if needed. After optimization of the general condition, pelvic ring fixation was done in a separate operative stage. Full clinical, neurovascular and radiological evaluation including an antero-posterior, inlet and outlet plain X-ray views and a CT scan with 2 mm cuts.

Using Tile [11] classification; 24 skeletally immature patients were included with unstable fracture pelvis. We excluded patients with stable fracture pelvis and neglected fractures more than three weeks. Anterior ring injuries were stabilized in 21 cases using external fixator in 17 patients and symphyseal plate in four patients after adequate closed/open reduction. Posterior ring injuries were stabilized using iliosacral screw in 16 cases. Pelvic (antero-posterior, inlet and outlet) views were taken intra-operative to assess the reduction adequacy. The performed fixation tactics and peri-operative sequel were recorded.

Patients are instructed to do early range of motion exercises and were advised to non-weight bear after four weeks, then gradually progress by full weight bearing at an average 7 weeks until radiological union occurs. In the follow-up clinic patients were reviewed at 2 weeks for sutures removal, then at 6 weeks, 3 & 6 months. For evaluation of union and pelvic symmetry during outpatient clinic visits, pelvic views (AP, inlet and outlet views) were taken. The Majeed score [12] at 3,6 months and last follow up postoperatively was used to measure functional outcome. Three factors were assessed and scored; pain, sitting and standing. We excluded the remaining two factors sexual intercourse and working because they played no role in life of our young age group of patients. The total being was a maximum of 76 points. Data were imported into Statistical Package for the Social Sciences [SPSS version 20.0] [Statistical Package for the Social Sciences] software for analysis. According to the type of data qualitative represent as number and percentage, quantitative continues group represent by mean ± SD, the following tests were used to test differences for significance. Difference and association of qualitative variable by Chi square test [X2]. Differences between quantitative independent groups by t test paired by paired t. P value was set at <0.05 for significant results & <0.001 for high significant result.

RESULTS

24 skeletally immature patients under sixteen years old years were included in our study with minimum 4 and maximum 14 (Mean± SD) was 8.25±2.86. Regard sex distribution male were 16 patients (66.7%) and females were 8 patients (33.3%). Table (1) & (4) Pedestrian injury [11 patients=45.8%] was the most common trauma mechanism then motor vehicle accident [7 patients=29.1%] followed by crush injury 3 patients=12.5%] and fall from height [3 patients=12.5%].Table (2) & (4)

All patients are classified according type to Tile classification where 18 cases were Tile's B [75%] and 6 cases were Tile's type C injuries [25%]. Table (2) & (4)

Combined iliosacral screw and anterior external fixator were the major type of fixation in 11 cases (45.9%) and the percutaneous approach was the majority in 20 patients (83.3%). Table (3) & (4)

The most commonly method of fixation was usage of one iliosacral screw for the posterior ring injury after successful closed reduction in 15 cases (62.5%). Only one case underwent open reduction through lateral window of ilioinguinal approach and fixation also by iliosacral screw. The closed reduction was successfully performed for anterior ring injuries in 17 cases (70.83%) and fixed by anterior external fixator. However open reduction and fixation by a symphyseal plate in

four patients (16.67%) was done. The radiological union distribution among studied group was minimum 6 weeks and maximum 10 weeks (Mean± SD) was 6.95±1.04. Table (3) & (4)

Majeed score distribution among studied group was significantly increased. Majeed score was at 3 months was 63.0±5.56 at 6 months was73.66±3.42 and at last follow up 75.25±2.51 (P<0.001). Figure (3)

Overall complication distribution among studied group was 7 cases (29.2%). Two cases had wound dehiscence, 3 cases had Pin track infection and 2 cases had neurological impairment. Complicated cases significantly longer in union and lower in Majeed score. Table (4)

Table (1): Age and sex distribution among studied group

		Age	
Mean± SD		8.25±2.86	
Median (Range)		7.5 (4-14)	
		N	**%**
Sex	**Female**	8	33.3
	Male	16	66.7
	Total	24	100.0

Table (2): Injury characters distribution among studied group

		N	%
Mechanism of injury	Crush injury	3	12.5
	Fall	3	12.5
	MVA	7	29.1
	Pedestrian	11	45.8
Associated injuries	None	14	58.3
	Yes	10	41.7
Classification	B1	2	8.3
	B2	16	66.7
	C1	6	25.0
Shock	Absent	16	66.7
	Present	8	33.3
Skin condition	Normal	20	83.3
	Lavell morell lesion	1	4.2
	Open	3	12.5
Neurovascular assessment	Intact	22	91.7
	Femoral vein injury	1	4.2
	Sciatic nerve injury	1	4.2
	Total	24	100.

Table (3): Management distribution among studied group

		N	%
Type of fixation	Ant external fixation	6	25.0
	Ilio sacral screw & ant ext fixator	11	45.9
	Ilio sacral screw	3	12.5
	Symphyseal plate	2	8.3
	Symphyseal plate & ilio sacral screw	2	8.3
Approach	lateral window ,pfannestiel kocher	1	4.2
	Percutaneous	20	83.3
	Pfannestiel approach	2	8.3
	Pfannestiel approach & percutaneous	1	4.2
	Total	24	100.0

Table (4): Summarized data and complications of the cases

		Not		Complicated		t/ X^2	P
Age		**7.64±2.26**		**9.71±3.77**		**1.669**	**0.109**
Radiological union		**6.58±0.71**		**7.85±1.21**		**3.217**	**0.004***
Majeed_score_3months		**65.35±3.18**		**57.28±6.15**		**4.270**	**0.00****
Majeed_score_6months		**75.11±1.79**		**70.14±3.97**		**4.291**	**0.00****
		N	**%**	**N**	**%**		
Sex	**Female**	**6 (35.3) %**		**2 (28.6)%**		**0.101**	**0.75**
	Male	**11 (64.7)%**		**5 (71.4)%**			
Mechanism of injury	**Crush injury**	**1 (5.9)%**		**2 (28.6)%**		**5.98**	**0.13**
	Fall	**1 (5.9)%**		**2 (28.6)%**			
	MVA	**7 (41.2)%**		**0 (0.0)%**			
	Pedestrian	**8(47.1)%**		**3 (42.9)%**			
Associated injuries	**None**	**11 (64.7)%**		**3 (42.9)%**		**0.97**	**0.32**
	Abd injury	**6 (35.3)%**		**4 (57.1)%**			
Classification	**B1**	**1 (5.9)%**		**1 (14.3)%**		**2.52**	**0.28**
	B2	**13 (76.5)%**		**3 (42.9)%**			
	C1	**3 (17.6)%**		**3 (42.9)%**			
Shock	**Absent**	**14 (82.4)%**		**2 (28.6)%**		**6.45**	**0.011***
	Present	**3 (17.6)%**		**5 (71.4)%**			
Skin condition	**Lavell morell lesion**	**0 (0.0)%**		**1 (14.3)%**		**5.28**	**0.071**
	Normal	**16 (94.1)%**		**4 (57.1)%**			
	Open	**1 (5.9)%**		**2 (28.6)%**			
Neurovascular assessment	**femoral vein injury**	**0 (0.0)%**		**1 (14.3)%**		**5.29**	**0.071**
	Intact	**17 (100.0)%**		**5 (71.4)%**			
	sciatic nerve injury	**0 (0.0)%**		**1 (14.3)%**			
Type of fixation	**ant. external fixation**	**4 (23.5)%**		**2 (28.6)%**		**7.85**	**0.096**
	iliosacral screw	**3 (17.7)%**		**0 (0.0)%**			
	Iliosacral screw&ant ext fixator	**9 (52.9)%**		**2 (28.6)%**			
	symphyseal plate	**1 (5.9)%**		**1 (14.3)%**			
	symphyseal plate & iliosacral screw	**0 (0.0)%**		**2 (28.6)%**			
Approach	**lateral window, pfannestiel kocher**	**0 (0.0)%**		**1 (14.3)%**		**6.09**	**0.107**
	Percutaneous	**16 (94.1)%**		**4 (57.1)%**			
	pfannestiel approach	**1 (5.9)%**		**1 (14.3) %**			
	pfannestiel approach & percutaneous	**0 (0.0)%**		**1 (14.3)%**			
Total		**17 (100.0)%**		**7 (100.0)%**			

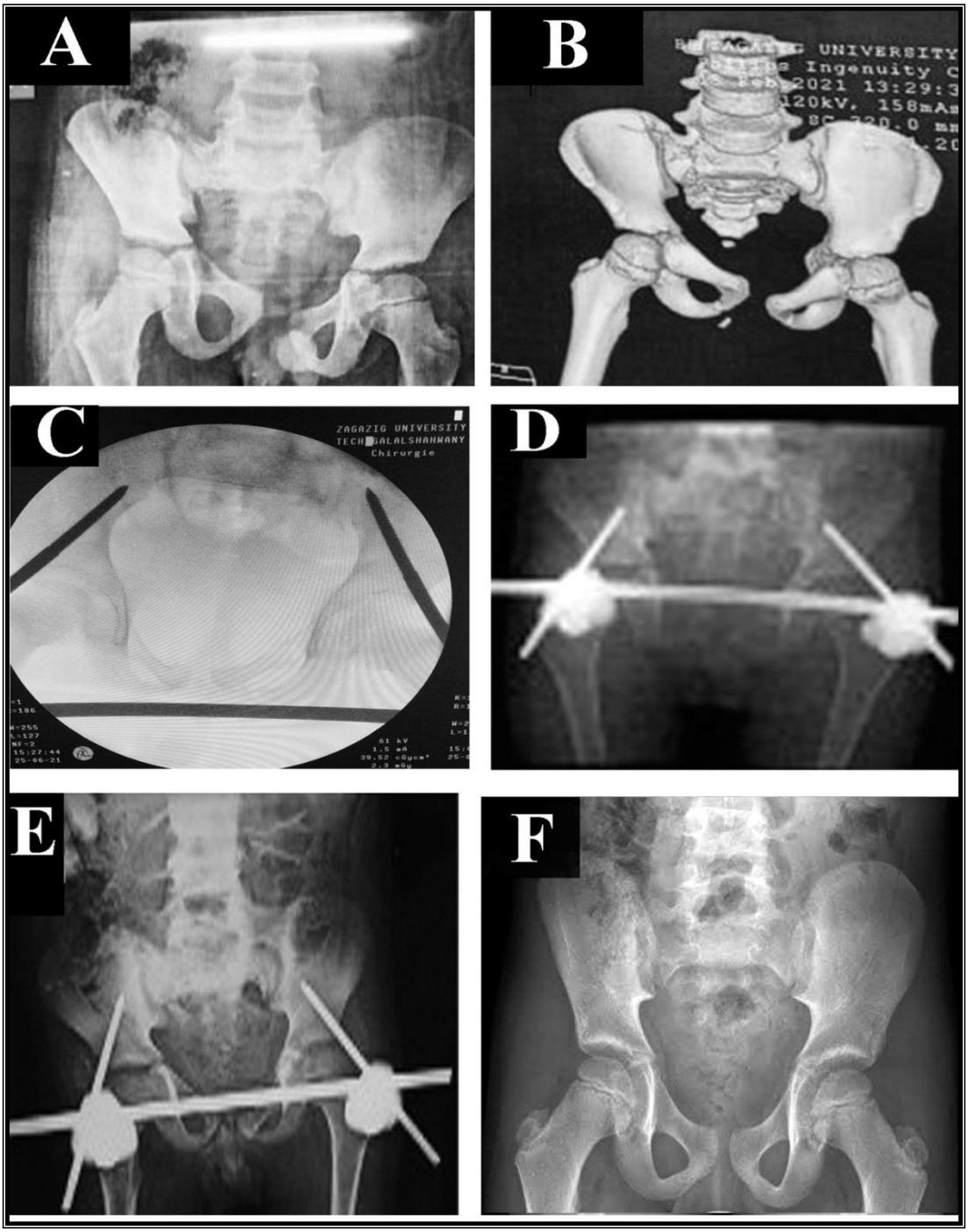

Figure (1): Six years old male patient with Rt. sacroiliac fracture and symphyseal pubis disruption managed by anterior external fixator in an X-frame to achieve posterior stability without need of iliosacral screw in this young patient .**A)** Preoperative AP x-ray on admission. **B)** Preoperative 3D reconstruction image. **C)** Intraoperative flouroscopy image. **D)** Immediate post- operative x-ray. **E)** Follow up radiograph after 6 weeks. **F)** Radiograph after 1 year follow up.

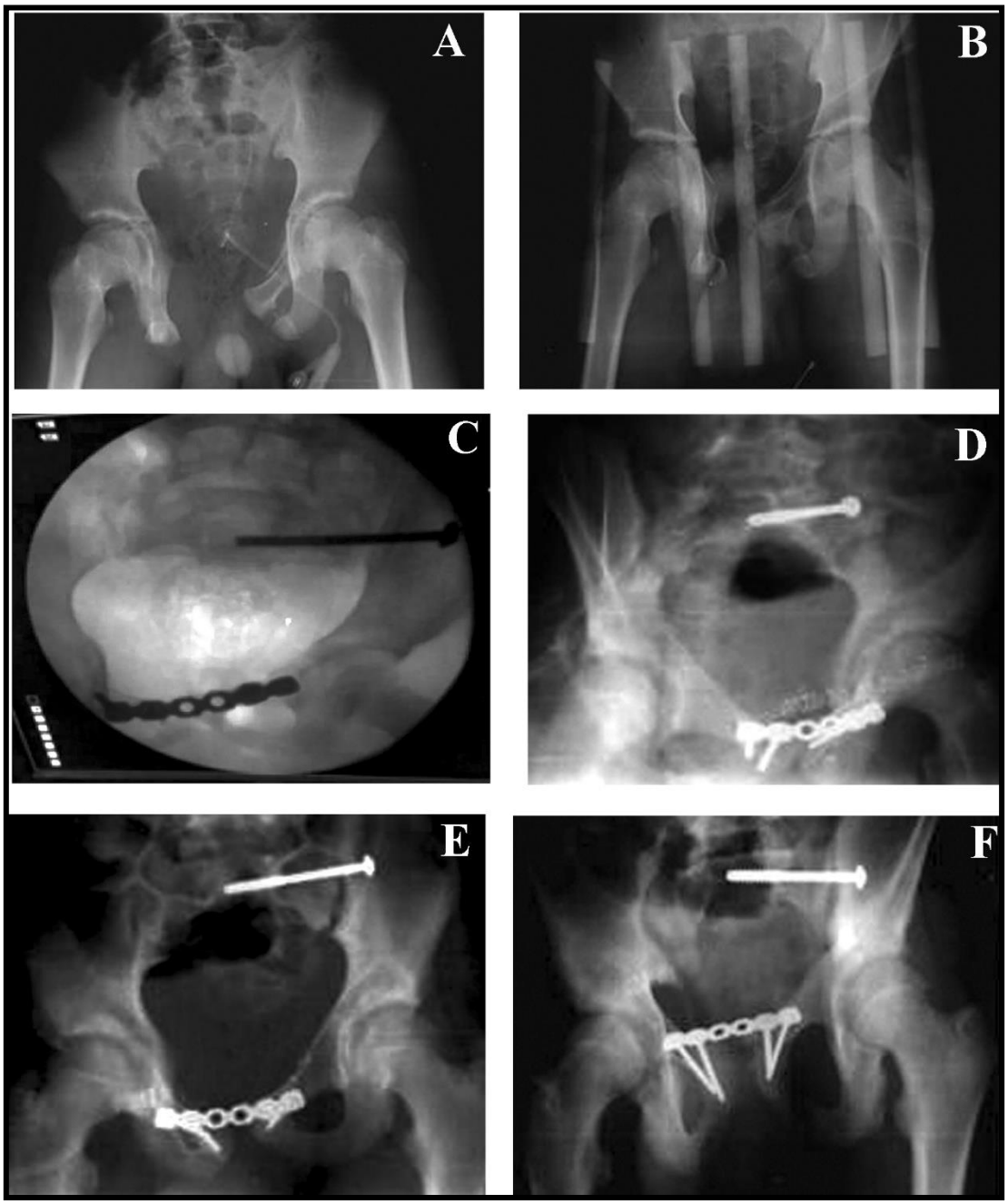

Figure (2): 14 years old male patient with open book fracture pelvis with hemodynamically unstable so pelvic binder was applied and patient was operated after being stable. Open reduction and fixation of symhyseal disruption by reconstruction plate using Pfannestiel approach. For posterior ring fixation; closed reduction and fixation by iliosacral screw. **A)** Radiograph of male patient at emergency department. **B)** After application of pelvic binder radiograph. **C)** Intraoperative image. **D)** Immediate post-operative x-ray. **E)** Follow up radiograph after 3 months**F)** Radiograph after 12 months follow up.

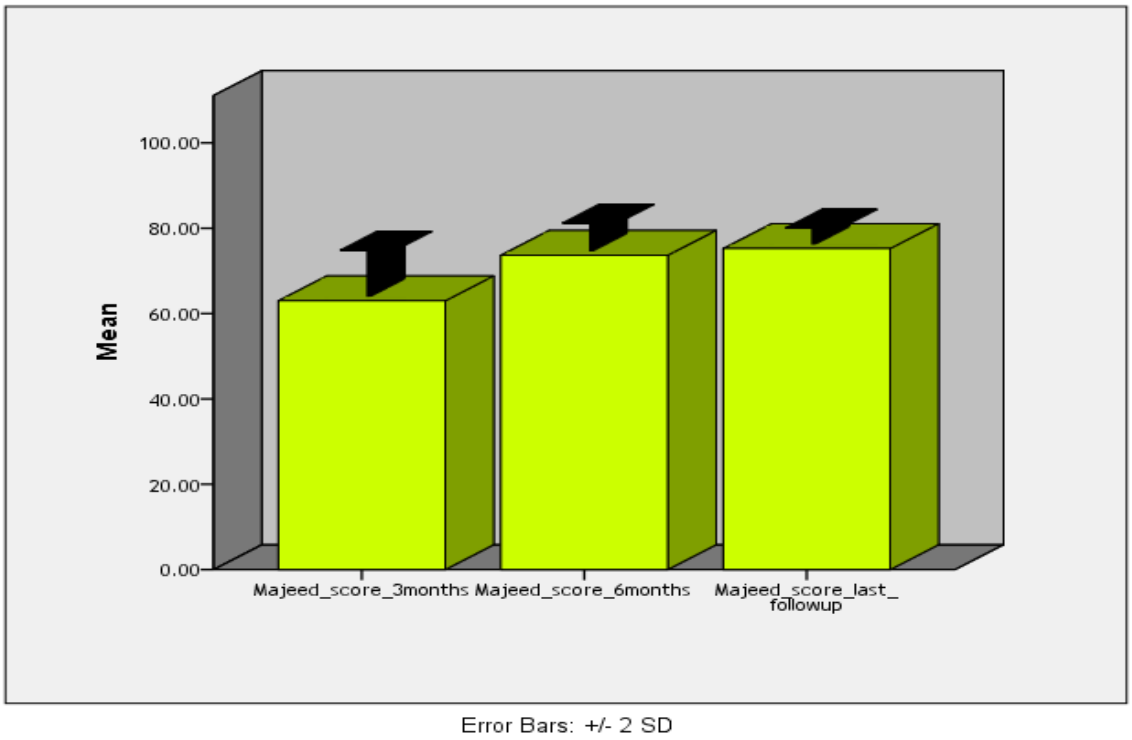

Figure (3): Majeed score distribution among studied group at 3 and 6 months and at last follow up

DISCUSSION

Despite pelvic fractures incidence in pediatrics is rare, may be complicated with substantial morbidity and mortality [3]. There are many debates in the literature about the best method for management of fracture pelvis in skeletally immature patients. Analyzing other studies on pelvic fractures in skeletally immature patients was in line with our study. Gänsslen et al. [4] analyzed a mean patient age of 9 years as well as male predominance with a male/female ratio of approximately 1.4:1. In our study the mean age was 8.25 and male/female ratio 2:1.

Agreeing with Leonard et al., [13] and Banjeree et al.,[14], all injuries were high-energy events and associated orthopedic injuries were common as in our study happened in 10 patients [43.3%]. Similar to that of the adult, traffic accidents are the most common cause of fracture pelvis in skeletally immature patients [15]. The number of cases done in our study is considered a relatively high incidence of pediatric pelvic fractures admitted at our hospital which is one of the biggest hospitals in Egypt serving millions of people reflecting less secure traffic in our country. Mussemeche et al., [16] stated that the incidence of hemorrhage in skeletally immature patients is low owing to vasoactive properties of their blood vessels in contrast to the more friable atherosclerotic adult vessels. In our series, hemorrhage leading to shock happened in eight patients (33.3%). Torode and Zeig [17] and Tile [11] systems classify pelvic fractures in skeletally immature patients to determine pelvic stability and to expect morbidity and mortality. Torode and Zeig [17] classified fractures into stable and unstable but do not differentiate between type of fracture and instability degree .The Tile [11] system differentiates between stable (type A), rotationally unstable (type B), and vertically unstable (type C) pelvic fractures [7].Our series depends on Tile classification owing to dealing with unstable fractures require surgical intervention; 18 cases were type B [75%] and 6 cases type C [25%]. While Subasi et al., [18]. Has reported 34 of the 58 fractures were type B and 24 were type C, Fahmy M & Abdelmoneim M [19] study was 21 cases; 9 patients were type B and 12 patients were type C.

Non operative management of displaced pelvic fractures in skeletally immature patients can lead to pelvic asymmetry and poor clinical outcomes [20]. Due to better knowledge of the fracture patterns and to avoid major significant sequel, surgical treatment is recommended recently during the last decade for fracture pelvis in skeletally immature patients [21].

There are small number of relevant studies for the surgical treatment of unstable fracture pelvis in skeletally immature patients due to the low rate

of the unstable cases and the effect of traditional conservative options [22] [23]. The standard indications for surgical intervention of pelvic fractures are: open fractures, control hemorrhage during resuscitation, in severe displaced fractures to prevent deformity and in poly-traumatized patients to optimize patient mobility [24].

The management of fracture pelvis in skeletally immature patients depends on fracture severity as patients with higher grade fractures need surgical treatment [25].

Non-operative treatment may cause unacceptably poor clinical outcomes; so Rieger et al., [26] recommended treatment these fractures with same principles matching to that of adult pelvic fracture management. As in other bones, the rate of development of the pelvis is rapid in the early five years old; then from five to ten years old is constant. After that acceleration of the growth of the pelvic bones occur above ten years of age to maturity. Up to forces of ten thousand N did not cause a fracture for the age of one year old. Up to the age of fourteen years old, forces of 3000–6000 N are required to result in a fracture or displacement of pubis symphysis and sacroiliac joints [27].

At the pubis symphysis and the sacroiliac joints, the pelvis in skeletally immature characterized by thicker cartilage and periosteum also ligaments are strong providing more stability, so high-energy force is required to result in pelvic fracture. Both growth plates and apophysis are weak anatomical sites; so, after injury to them, premature closure of the growth plates and growth arrest can occur [28].

In the emergency department great effort should be done for hemodynamically unstable patients. A pelvic binder could be put over the greater trochanters in these patients [29]. Use of pelvic binder has advantages as a rapid and non-invasive tool but it cannot be used as a permanent stabilization of the pelvis [30].

For fixation of anterior ring use of external fixator as a minimally-invasive, easy technique with a strong purchase and no time- consumption is often performed [4].

The anterior external fixator is an excellent instrument to close down the anterior ring providing mechanical stability and definitive treatment for type B especially when the posterior ligaments are intact. External fixators are applied in a percutaneous manner by placing pins the supra-acetabular region or in in the iliac crests. Supra acetabular pins are better due to stronger bone purchase in the sciatic buttress and a better vector to close anterior ring. Placement of pins in the iliac crests can be performed in the emergency room with or without fluoroscopy [31, 32]. However, poor patient compliance, aseptic loosening and pin track infection are disadvantages of external fixation [33]. In our series; 3 cases suffered from pin track infection and fortunately relieved completely after removal of the implant.

The anterior subcutaneous internal fixator is an alternative to the anterior external fixator used in fracture pelvis in skeletally immature patients to overcome problems of external fixation but it is more expensive and less suitable in the emergency department [19]. For unstable fractures (Tile C) an anteriorly based fixator cannot in achieve posterior compression for posterior pelvic ring disruptions. By modifying the anterior frame into an X configuration, anterior external fixator could be used to compress posterior ring disruptions [34, 35].

Patients treated with an anterior external fixation alone had more residual pelvic-asymmetry than those treated with both anterior and posterior fixation [36]. Iliosacral screw used for acute percutaneous stabilization of the posterior pelvic ring requires technique familiarity to be performed accurately and rapidly [37]. Misplacement of the screw resulting in inaccurate reduction, vascular or neurologic injuries, and mechanical failure of fixation are the main risks of this technique [38].

By using the strongly purchased half pin Schanz in the supra-acetabular area Starr et al., [39] manipulate easily and optimally reducing the displaced hemipelvis. The reduction technique of anterior ring is done by placing pins into the iliac bone above the acetabulum and using manual longitudinal traction for posterior ring fracture then fixed with percutaneous IS screw [40]. ORIF can be performed in a patient who is otherwise clinically stable however; the iatrogenic risk of stopping pelvic growth due to the surgical approach in addition to bone remodeling opportunities can overcome the advantages of internal fixation in a younger child [41]. There is no requirement for internal fixation of the anterior ring in skeletally immature patients as they have excellent healing potential [42].While Scolaro et al., [43] use percutaneous iliosacral screw [IS] for posterior ring fixation in sixty-seven pediatric pelvis fractures in addition to fixation of anterior ring in thirtythree cases giving satisfactory

clinical and radiographic results with no reduction loss with a mean follow-up 33 weeks, Oransky et al., [44] treated eight unstable fracture patients surgically with plates and screws. Other authors reached the same agreement that surgical intervention in unstable fracture pelvis in skeletally immature patients is obligatory and anatomical reduction of the fracture should be done as it is in adults [45-48].

In this study unstable fracture pelvis in 24 cases of skeletally immature patients were operatively treated by different techniques, implants and approaches. Combined ant external fixator& iliosacral screw were the major type of fixation in 11 cases (45.9%) and the percutaneous approach performed in 20 patients (83.3%). The disruption of anterior ring was successfully closed reduced in 17 patients and fixed by anterior external fixator. However open reduction and fixation by a symphyseal plate in four patients was done. The closed reduction was successful using one iliosacral screw for the posterior ring injury in 15 cases (62.5%). Only one case underwent open reduction fixation by iliosacral screw using ilioinguinal approach through lateral window. Anterior external fixation alone was done in 6 cases [25%]. By Modification into X frame, the anterior external fixator was applied in one case with posterior ring injury without need of sacroiliac screw fixation.

Radiological evaluation of the surgical management of pelvic fractures in skeletally immature patients in our study reveals fracture union in all cases was minimum 6 weeks and maximum 10 weeks (Mean± SD) was 6.95±1.04. In accordance with other studies, our results of surgical fixation shared a similar conclusion.

We used the Majeed scoring system [11] for functional outcome evaluation because it is specific for pelvic fractures which gave us solid objective data. We excluded two factors sexual intercourse and working because they played no role in life of our young age group of patients. 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 at last follow up. Gobba et al., [49] reported that Majeed scoring system is applicable in skeletally immature patients after modification. In our study, score significantly increased. Majeed score was at 3 months 63.0±5.56, at 6 months was73.66±3.42 and at last follow up 75.25±2.51 (P<0.001). Overall complication distribution among studied group occurred in 7 cases (29.2%). Two cases had wound dehiscence managed by repeated dressing; one of them complete cure had been achieved and the other case needed skin graft.3 cases had Pin site infection and fortunately subsidence occurred after removal of implant without sequel. Taking our study's data and the literature into account, operative intervention using different techniques & implants is appropriate, efficient and valid for unstable pelvic fractures in skeletally immature patients. We cannot determine if growth arrest will occur either due to high energy trauma or as a result of fixation effect on growth centers.The limitation of this study was inability to assess delayed sequel because the duration of follow-up is relatively short and rare incidence of these fractures.

CONCLUSIONS

Based on this current study the surgical treatment for unstable pelvic fractures gives us valuable results, so we could recommend this choice of surgical intervention to decrease long-term sequelae. Long term follow-up, large scale multicenter and meta-analysis are required to understand the best method of management of pelvic fractures in skeletally immature patients.

Conflict(s) of interest: None

Financial Disclosures: None

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