Percutaneous Fixation of Combined Pelvic and Acetabular Fractures

Almohamdy Alawady Almohamdy Agag, Amr Mohamed Al-Adwy, Ahmed Elsayed Elmalt

Orthopedic department, Faculty of medicine, Zagazig University, Egypt.

Corresponding Author: Almohamdy Alawady Almohamdy Agag

E-mail: almohamdyagag@gmail.com

ABSTRACT

Background: Despite improvements in surgical technique and approach, functional outcomes don't always yield the desired outcome. New percutaneous treatment techniques have been developed to maintain anatomic reduction and stable fixation of the pelvic and acetabular fractures. Patients and Methods: At Zagazig University's Faculty of Medicine, in the orthopaedic department, we conducted a clinical trial study with 18 patients. Clinical and radiological evaluations both before and after surgery were performed. Results: The average age of the study group was (33.5) years. About three-quarters were males (72.2%). Motor vehicle accidents were the most common mode of injury (72.2%). More than half of the study group had a transverse fracture (66.7%). The sacro iliac joint disruption was associated in (33.3%) of cases. Anterior and posterior screws with ileosacral screws were the most common type of fixation among the studied group (27.8%), with average days till surgery of (3.7). Regarding the outcome, the anatomical outcome was gained in half of the studied group (50.0%) and a satisfactory outcome was gained in (44.4%), while only one case (5.6%) had an unsatisfactory outcome. More than two-thirds (72.2%) had an excellent Merle d'aubigné score. There were no postoperative complications in most cases (88.9%), and only 2 cases (11.1%) had medial cortex penetration. Conclusion: Percutaneous screw fixation is a safe and effective procedure with little morbidity and complication risk for patients with combined pelvic and acetabular fractures .

Keywords: Acetabular fracture, Pelvic fracture, Percutaneous Approach.

Tob Regul Sci. ™ 2023;9(1): 1414-1427

DOI: doi.org/10.18001/TRS.9.1.96

INTRODUCTION

There is a significant risk of morbidity and mortality associated with pelvic ring and acetabular fractures due to significant internal organ injury and hemorrhage (**Zhao et al., 2018**). 3% of skeletal injuries are pelvic and acetabular fractures. According to studies, the annual incidence of pelvic ring fractures is 23 per 100,000 people, while that of acetabular fractures is three per

100,000 people. These fractures can be caused by low-energy injuries like falls in elderly people with osteoporosis or by high-energy traumatic injuries. (**Singh et al., 2022**)

Orthopedic surgeons are faced with a significant challenge when treating these fractures. Early surgical fixation of pelvic ring fractures (PRF) and acetabular fractures (AF) is the preferred course of treatment because it offers a number of benefits, including early ambulation and decreased morbidity and mortality. The ideal fixation technique, particularly for unstable fractures, is still up for debate. Open reduction internal fixation (ORIF) necessitates considerable exposure and is linked to a number of intra- and postoperative complications, including massive hemorrhage, deep vein thrombosis, neurovascular injuries, heterotopic ossification (HO), and infection. (**Qoreishi et al., 2019**)

Since Routt et al., 1995 first described closed reduction using percutaneous screw fixation, numerous authors have applied this minimally invasive technique to the care of patients with PRF. The main benefits include less soft tissue injury, less blood loss, and a lower rate of infection. However, some issues with the procedure could arise, including a higher risk of neurovascular injuries, internal organ damage, screw misplacement, and screw fracture. (**Chui et al., 2018; Eckardt et al., 2017; Tempelaere, Vincent & Court, 2017; Fang, Alabdulrahman & Pape, 2017**)

Closed reduction with percutaneous fixation of non-displaced or minimally displaced fractures of the acetabulum under CT or fluoroscopic guidance has received interest due to recent developments in imaging technology and computer navigation. (**Chui et al., 2018**)

PATIENTS AND METHODS

A clinical trial study was conducted on 18 patients where percutaneous fixation of combined pelvic and acetabular fractures was applied in the Orthopedic department, Faculty of Medicine, Zagazig University. Approval taking (Institutional Review Board (IRB) approval) and also informed written consent was conducted among patients and/or their caregivers. The Declaration of Helsinki, the World Medical Association's code of ethics for studies involving humans, was followed in the conduct of this work. **Inclusion criteria:** pelvic ring and acetabular fractures, transverse fracture acetabulum with minimal displaced small posterior wall and surgically fit patients. **Exclusion criteria:** Pediatric patients, patients with fracture acetabulum with neurovascular insult, patients with old united fracture, comminuted and markedly displaced acetabular fractures and surgically unfit patients.

Pre-operative assessment:

The clinical and radiological status of every patient was fully evaluated. Each patient underwent a clinical evaluation (history, general and local examination), radiological evaluation of the pelvic and acetabular fractures, including standard X-rays. Additionally, thin-section computed tomography (CT), multiplanar reconstructed images, and, if reasonable, surface-rendered three-

dimensional (3D) reconstruction with or without disarticulating the proximal femur. the patient was investigated and prepared for surgery (CBC, liver functions, kidney functions, coagulation profile and blood sugar, ECG for patients older than 40).

Operative technique:

Under general anesthesia, all patients were operated on a radiolucent table, patients were laid out supine. The operative side should be positioned close to the table's edge for easier access to the hip. The arms should be positioned with their elbows abducted on the armrests to prevent the C-arm from being obstructed during the inlet view. An indentation under the hip or pelvis is not necessary for the procedure. A cloth covering the surgical site has been set up. Left exposed are the ipsilateral hemipelvis, proximal thigh, and buttocks (10 cm above the iliac crest). To demarcate the area, sterile towels are stapled together. The area is then ready and U-drapes are placed around the surgical field. Before draping, the distal portion of the ischial tuberosity must be accessible if a retrograde posterior column screw is planned, and the patient's hip must be able to completely flex more than 90 degrees and abduct freely without any restrictions. The adjustable C-arm is located on the opposite side of the table from the fixed C-arm. The entire procedure is managed closely by a fluoroscope. Before preparing the patient and draping him or her, the surgeon must make sure that during the procedure, good antero-posterior, the two Judet-oblique views (iliac and obturator), pelvic in-let and outlet views can be obtained to confirm safe screw placement. Inadequate imaging may make it difficult to correctly position the K wire, which is very challenging. Surgical procedures employ antibiotics in accordance with hospital policy. The landmarks to be recognized are the greater trochanter, the lateral aspect of the femur, the anterior inferior iliac spine, the anterior superior iliac spine, and the distal most aspect of the ischial tuberosity. We fixed any displaced fractures of the anterior pelvic ring after fixing the acetabular fracture, then we fixed any fractures of the posterior pelvic ring. Fixation was accomplished using a variety of implants, including plates (either 3.5mm or 4.5mm reconstruction plates) and screws (partially threaded cannulated 6.5mm, 7.3mm screws). The Hoffmann type of external fixator was employed. Wound closure was done in layers on a closed suction drain size 18.

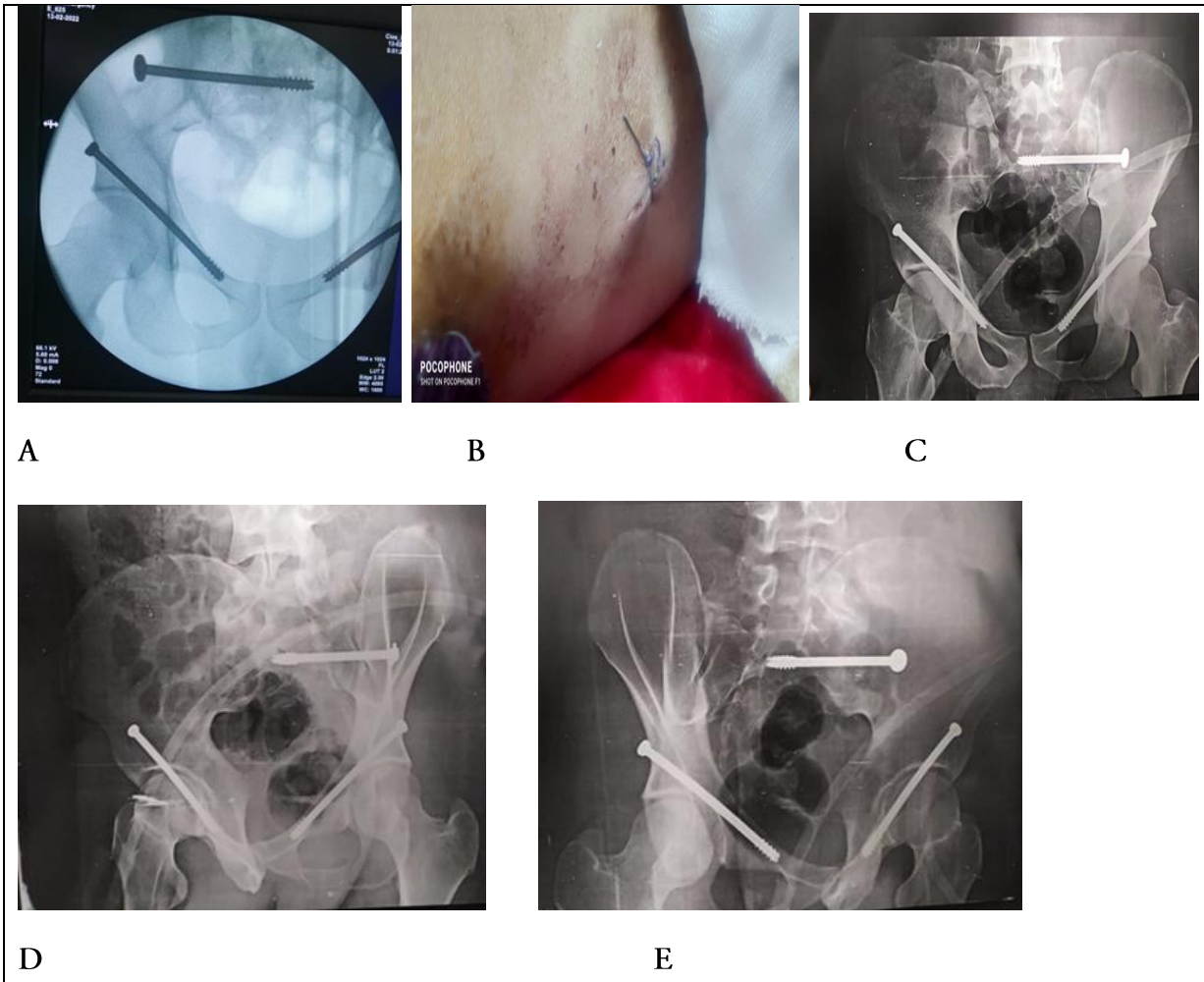
Post-operative follow-up:

General observations of the patient, and the vital signs were checked. Anticoagulants, indomethacin, and broad-spectrum parenteral antibiotics were administered to the patients. The patient was examined for limb length, neurological conditions, and the presence of distal pulses after surgery. The condition of the wound was also looked at. We used closed suction drains on all of the patients for a period of 48 hours. Patients were transferred as soon as possible to a chair, typically on the second postoperative day. In our patients, weight bearing with a walker was initiated as soon as possible, especially when the acetabular and pelvic components had both undergone surgical fixations. After six weeks, the patient was allowed to bear some weight

partially, and full weight bearing was allowed after twelve weeks, as determined by a radiographic evaluation of the fracture's satisfactory union. Partial weight bearing for up to 12 weeks was used in cases of severe comminution, osteoporosis, and marginal impaction. After six weeks, the anterior external fixator was removed. Radiographs of the pelvis from an AP angle, the obturator and iliac oblique views, as well as the inlet and outlet views, were taken in order to evaluate each patient postoperatively. A postoperative CT scan was carried out in some cases to examine whether marginal impaction had been correctly repaired and to look for any intraarticular hardware in uncertain cases. Patients were followed up with every two weeks during the first month. Routine X-rays were performed at every follow-up. We followed up on every case for nine to twelve months. Utilizing the Merle D'Aubigne grading system, the clinical outcomes at the final follow-up were assessed.

Statistical analysis

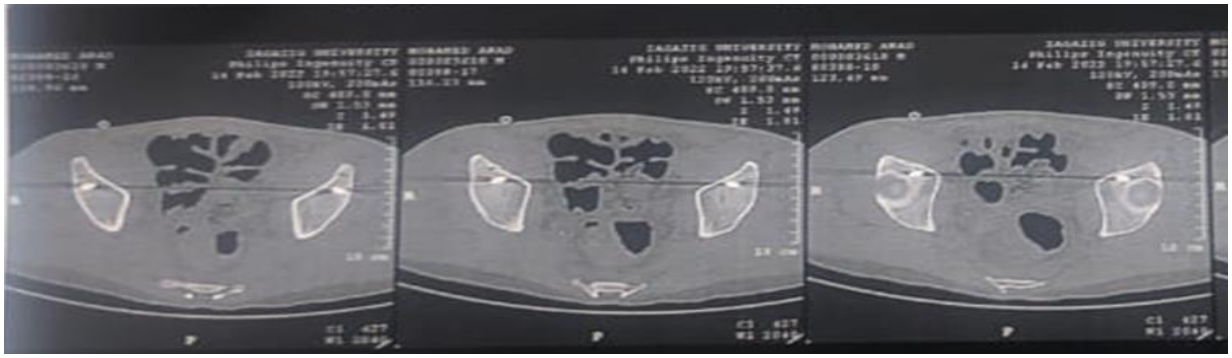
Data analysis was performed using the software SPSS (IBM) version 25. Quantitative variables were described using their means, standard deviations, median, and range. Categorical variables were described using their absolute frequencies and were compared using a chi-square or Fischer Exact test when possible. The level of statistical significance was set at P≤0.05.



A B C

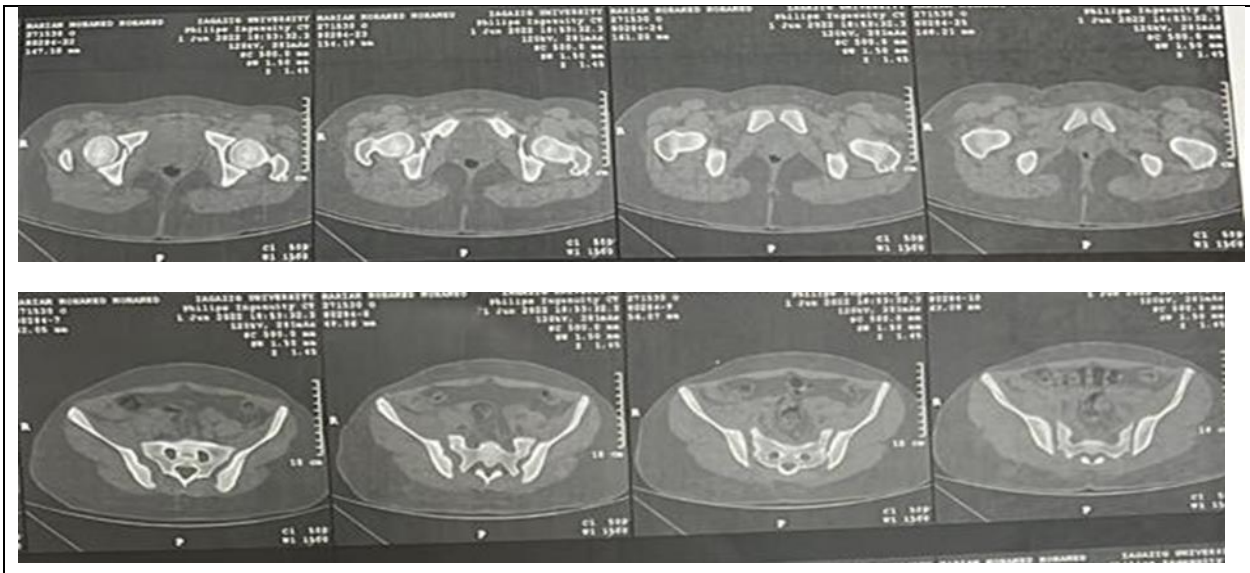
D E

F

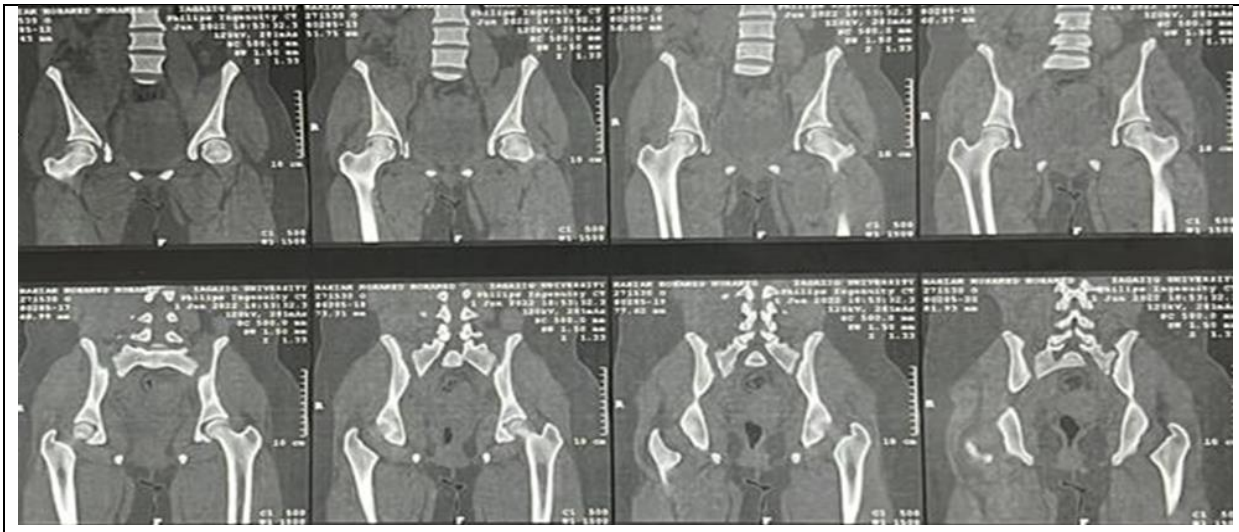


G

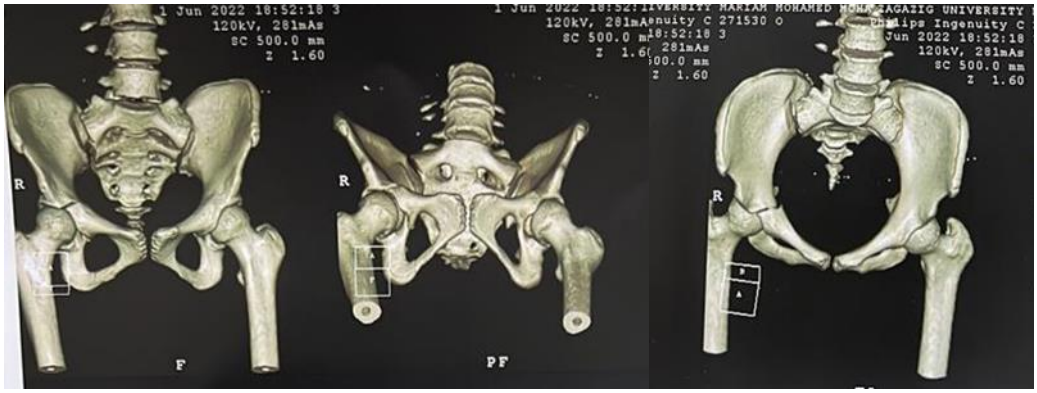
Fig. (1): A (C arm, AP view), B (Skin closure), C (Post operative X- ray, AP view), D, E (Post operative X-ray, Obturator & iliac oblique views) & F, G (Post operative CT: Sagittal & axial cuts).



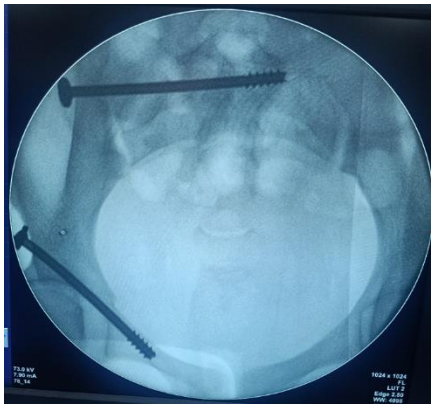
A



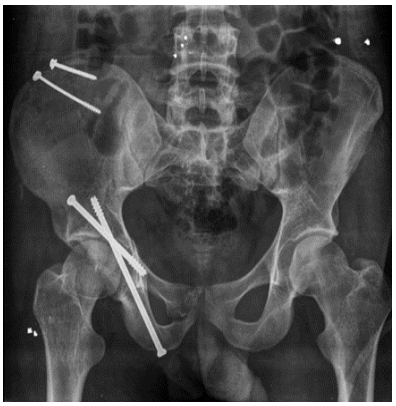
B



C



D



E

F

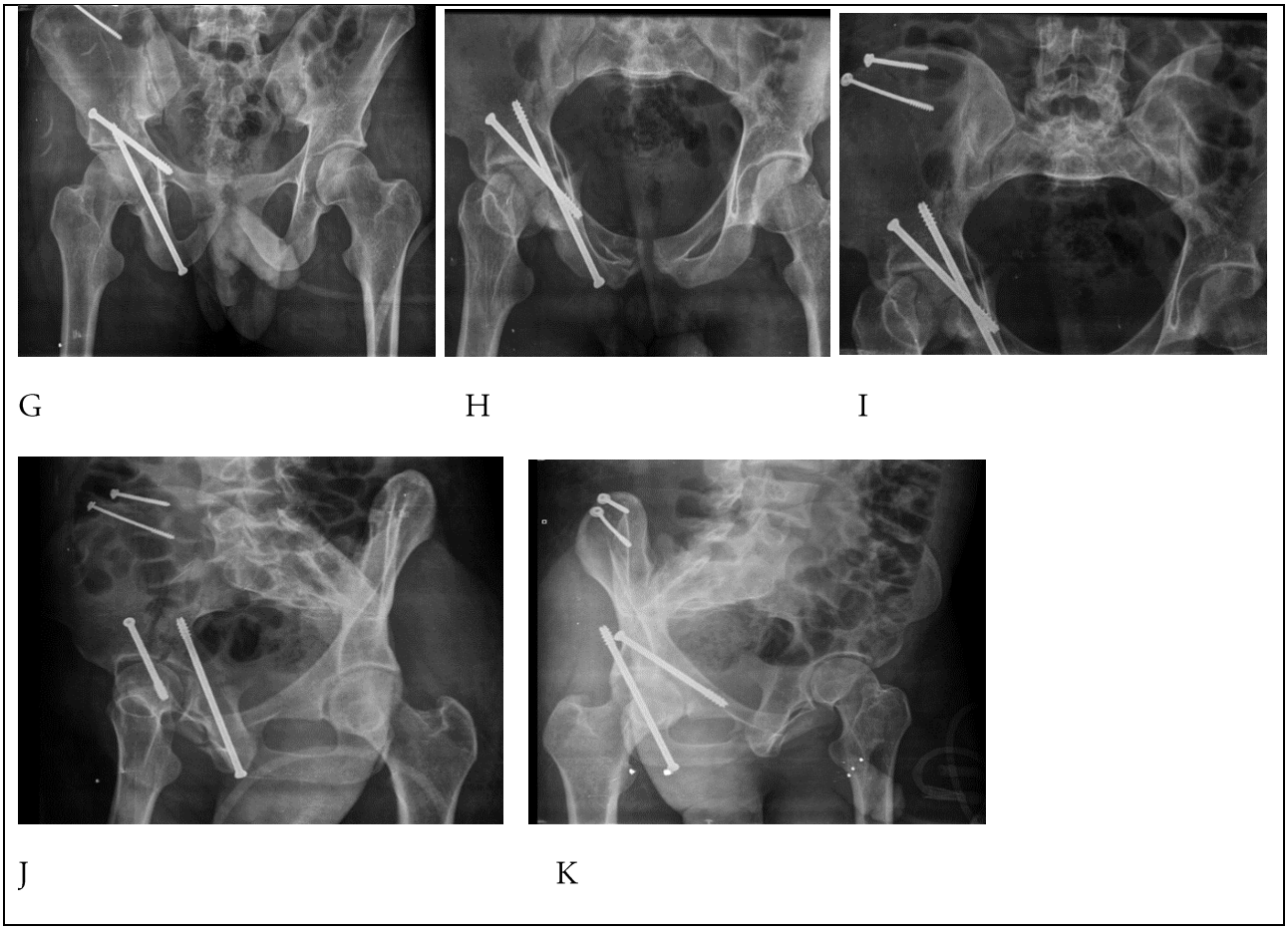


Fig. (2): A, B &C (pre op CT axial, sagittal & 3D cuts); D (C arm AP view); E (Post op AP view); F, G, H, I, J &K (Post op Pelvic & acetabular views); I, J,K (pre op CT axial, sagittal & 3D cuts).

RESULTS

The average age of the studied group was 33.5 years. About three-quarters were males (72.2%) while (27.8%) were females. The majority of them (77.8%) were married, (50.0%) were hand workers, and (11.1%) were carpenters (Table 1).

Motor vehicle accident was the commonest mode of injury (72.2%) followed by fall from height (16.7%). More than half of the studied group had a transverse fracture (66.7%) followed by a posterior fracture (22.2%) and then an anterior column (11.1%). The sacro iliac joint (SIJ) disruption was associated in (33.3%) of cases while the iliac wing and symphyseal disruption were associated in (27.8%) of cases. ant & post screws with ileosacral screws were the most used type of fixation among the studied group (27.8%) with average days till surgery of 3.7 ranging from one to 7 days as shown in table (2). Regarding the outcome, the anatomical outcome was gained in half of the studied group (50.0%) and a satisfactory outcome was gained in (44.4%) while only one case (5.6%) had an unsatisfactory outcome, more than two-thirds (72.2%) had an excellent merle d'aubigné score, (22.2%) had a good merle d'aubigné score and one case (5.6%)

had fair merle d'aubigné score. There were no postoperative complications in most cases (88.9%) and only 2 cases (11.1%) had medial cortex penetration.

There was a statistically significant association between postoperative complications with the radiological outcome and merle d'aubigné Score where non-complicated cases had better outcomes than complicated cases while no statistically significant association with patients' characteristics (Table 3)

Table (1); Socio-demographic characteristics of the studied group: -

Demographic data	The studied group
	No=18 (%)
Age (years)	
Mean ± SD	33.5±13.7
Median	31.0
(Range)	(18-70)
Sex	
Male	13 (72.2%)
Female	5 (27.8%)
Marital status	
Married	14 (77.8%)
Unmarried	4 (22.2%)
Occupation	
Peddler	1 (5.6%)
Hand worker	9 (50.0%)
Carpenter	2 (11.1%)
Employee	1 (5.6%)
Plumber	1 (5.6%)
Technician	1 (5.6%)
Painter	1 (5.6%)
Student	1 (5.6%)
Teacher	1 (5.6%)

Data expressed as Mean ± SD or number (percent).

Table (2): Clinical data of the studied group: -

Clinical data	The studied group
	No=18 (%)
Mode of injury	
Pedestrian	1 (5.6%)
motor vehicle accident	13 (72.2%)

Motorcycle	1 (5.6%)
Fall from height	3 (16.7%)
Type of fracture	
Ant. Column	2 (11.1%)
Post. Column	4 (22.2%)
Transverse	12 (66.7%)
Associated injury	
SIJ disruption	6 (33.3%)
Iliac wing	5 (27.8%)
Symphyseal disruption	5 (27.8%)
Sacrum fracture	2 (11.1%)
Days to surgery	
Mean ± SD	3.7±2.1
Median	3.5
(Range)	(1-7)
Type of fixation	
Ant & post screws+ Closed percutaneous crossing screws	3 (16.7%)
Ant & post screws+ Ileosacral screw	5 (27.8%)
Ant & post screws+LC2	4 (22.2%)
Anterior columnar screw	1 (5.6%)
Anterior columnar screw+ Closed percutaneous crossing screws	1 (5.6%)
Post columnar screw+ Closed percutaneous crossing screws	1 (5.6%)
Post columnar screw+ Ileosacral screw	2 (11.1%)
Post columnar screw+LC2	1 (5.6%)

Table (3): The outcome of the studied group: -

The outcome	The studied group No=18 (%)
Radiological outcome	
Anatomical ≤ 1mm	9 (50.0%)
Satisfactory 2-3 mm	8 (44.4%)
Unsatisfactory >3mm	1 (5.6%)
Merle d'Aubigné Score	
Excellent	13 (72.2%)
Good	4(22.2%)
Fair	1 (5.6%)
Complications	
No	16 (88.9%)
Medial cortex penetration	2 (11.1%)

Table (4): Relation between the postoperative complications with patients' characteristics and outcomes among the studied group: -

Variables	Non-complicated cases No. = 16 (%)	Complicated cases No. =2 (%)	p-value	Odds ratio 95% CI
Age				
≤ 31 years(no=15)	14 (93.3%)	1 (6.7%)	0.08^	1.4(0.8-2.2)
>31 years(no=9)	6 (66.7%)	3 (33.3%)		
Sex				0.8
Male (no=13)	11 (84.6%)	2 (15.4%)	0.9^	(0.67-1.06)
Female(no=5)	5 (100.0%)	0 (0.0%)		
Marital status				1.2
Married(no=14)	13 (92.9%)	1 (7.1%)	0.4^	(0.69- 2.2)
Unmarried(no=4)	3 (75.0%)	1 (25.0%)		
Mode of injury	1 (100.0%)	0 (0.0%)	0.8^^	
Pedestrian(no=1)				
motor vehicle accident(no=13)	11 (84.6%)	2 (15.4%)		
Motorcycle(no=1)	1 (100.0%)	0 (0.0%)		
Fall from height(no=3)	3 (100.0%)	0 (0.0%)		
Type of fracture				
Ant. Column(no=2)	2 (100.0%)	0 (0.0%)	0.6^^	
Post. Column(no=4)	4 (100.0%)	0 (0.0%)		
Transverse(no=12)	10 (83.3%)	2 (16.7%)		
Days till surgery				
≤ 4 days(no=12)	8 (61.5%)	4 (80.0%)	0.6^	
> 4 days (no=6)	5 (38.5%)	1 (20.0%)		
Radiological outcome				
Anatomical ≤ 1mm (no=9)	9 (100.0%)	0 (0.0%)		
Satisfactory 2-3 mm (no=8)	7 (87.5%)	1 (12.5%)	**0.01*^^**	
Unsatisfactory >3mm (no=1)	0 (0.0%)	1 (100.0%)		
Merle d'Aubigné Score				
Excellent (no=13)	12 (92.3%)	1 (6.3%)		
Good (no=4)	4 (100.0%)	0 (0.0%)	**0.02*^^**	
Fair (no=1)	0 (0.0%)	1 (100.0%)		

*Statistically significantly different, ^P-value for Fischer Exact test. ^^ P-value for Chi-square test.

DISCUSSION

The significance of this study is highlighted by the fact that, in some circumstances, acetabular and pelvic fractures may be managed by minimally invasive techniques using percutaneous approach because it is linked to positive clinical outcomes and involve fewer soft tissue complications.

Even the most talented orthopedic surgeons face a significant hurdle when treating acetabular and pelvic fractures. The infrequent incidence, the complex operative anatomy, and the frequent presence of co-morbid injuries all contribute to the intrinsic difficulties in treating these fractures. (**Mansour et al., 2022**)

The immediate stability that is attained following percutaneous fixation allows for early mobilization of weight bearing. Reduced operative morbidity, blood loss, time required for the procedure, wound healing, infection, and blood loss are all benefits over formal open procedures that are more attributable to the open procedure than the fractures themselves. (**Bozzio et al., 2014**)

Regarding our result, the average age of the studied group was 33.5 years. About three-quarters were males (72.2%) while (27.8%) were females. The majority of them (77.8%) were married, (50.0%) were hand workers, and (11.1%) were carpenters. That was close to **Obey et al., 2022** who perform a study on Percutaneous Posterior Pelvic Ring Reduction and Fixation and reported 59 % of the studied group were male individuals, with a mean age of 37.9 years.

Additionally, Qoreishi et al., 2019 reported the mean age of the studied group was 29+7 and male gender represented 66.5% of the studied group.

In our study, motor vehicle accident was the commonest mode of injury (72.2%) followed by fall from height (16.7%). That was close to **Kolesnik et al., 2020** who reported that motor vehicle crashes are the most common cause of pelvic fractures that occur in 70.4 % of the cases. That was also supported by the results of **Kusturova & Kusturov, 2017** and the results of **Negrin & Seligson, 2017**.

However, **Singh et al., 2022** reported the most common mechanisms of injury were road traffic accidents (53.8%), falls (33.1%) and crush injuries (13.0%). **El-badawy et al., 2020** reported Mode of injury was road traffic accident in 58.3% of cases and fall from height in 41.7%, but it was a small sample size and cannot be generalized.

Regarding type of the fracture in our study, more than half of the studied group had a transverse fracture (66.7%) followed by a posterior fracture (22.2%) and then an anterior column (11.1%). That was in agreement with **Veerappa et al., 2020** who reported that the transverse acetabular fracture pattern is the commonest followed by associated both column fractures in a systematic review of combined pelvic and acetabular injuries.

In our study, the SIJ disruption was associated in (33.3%) of cases while the iliac wing and symphyseal disruption were associated in (27.8%) of cases. That was close to **Banaszek, Starr & Lefaivre, 2019** who reported that anterior pelvic ring can be complicated by disruption of the posterior pelvic ring, such as to the sacroiliac (SI) joint, in up to 40% of cases.

Ant & post screws with ileosacral screws were the most used type of fixation among our studied group. **Qoreishi et al., 2019** performed iliosacral or transsacral screw in most of the studied group.

In our study, the average days till surgery was 3.7 ranging from one to 7 days. That was close was **Navas et al., 2022** who reported the mean time until definitive stabilization of the pelvic fracture (7.3 ± 4 days vs. 5.4 ± 8.0 days; p = 0.147).

Regarding the outcome in our study, the anatomical outcome was gained in half of the studied group (50.0%) and a satisfactory outcome was gained in (44.4%) while only one case (5.6%) had an unsatisfactory outcome, more than two-thirds (72.2%) had an excellent merle d'aubigné score, (22.2%) had a good merle d'aubigné score and one case (5.6%) had fair merle d'aubigné score. There were no postoperative complications in most cases (88.9%) and only 2 cases (11.1%) had medial cortex penetration. That was close to **Qoreishi et al., 2019** reported that Within the first three months following surgery, every fracture had healed. Additionally, 93% of patients were able to resume their pre-injury jobs. there were no thromboembolic events, or neurovascular injuries. Postoperative complications occurred at a rate of 1.4% overall. Additionally, there was only one screw failure and no screw breakage was noted.

Additionally, **Tempelaere et al., 2017** evaluated the results of 11 patients' percutaneous posterior fixation of pelvic ring fractures at 4 years. Without intraoperative complications, the radiological and functional results were good to excellent.

However, **Chui et al., 2018** reported one delayed union occurred at seven months in a 72-year-old woman with an insufficiency fracture. On post-operative CT, one sacroiliac screw (0.7%) was found to have a 1-mm cortical perforation at the ipsilateral sacral foramen without screw loosening; the patient had no neurological deficit. With no signs of impingement, 19 screws (12.7%) backed out for an average distance of 5.3 mm. All other backout screws were from fractures that had already healed with callus, with the exception of the four screws that backed out in the insufficiency fracture case. At the most recent check-up, 20 patients (52%) could walk without assistance, nine (24%) could with a stick, and seven (18%) could with a frame.

Due to variations in patient age and patient selection, particularly with regard to the type of fractures, some measurements in the study mentioned above were inconsistent. The use of various techniques and modalities can also have a big impact on the measures. It should be noted that percutaneous screw placement requires technical skill and requires some practice. The surgeon's ability to place the screws accurately and quickly will improve with more experience.

The surgeon's skill and experience also prevented neurovascular injury, as demonstrated in the current study, when using advanced modalities.

Our study's limitations include a small number of patients, there was no randomization and the study was single center study so we cannot do generalization to the data.

We recommend further studies taking large sample size and performing multicentric studies so we can generalize the data.

CONCLUSION:

The obtained results are encouraging and show that percutaneous screw fixation with minimal invasiveness is a safe and effective procedure with little morbidity and complication risk for patients with combined pelvic and acetabular fractures.

REFERENCES

1. **Banaszek, D., Starr, A. J., & Lefaivre, K. A. (2019).** Technical considerations and fluoroscopy in percutaneous fixation of the pelvis and acetabulum. JAAOS-Journal of the American Academy of Orthopaedic Surgeons, 27(24), 899-908.
2. **Bozzio, A. E., Wydra, F. B., Mitchell, J. J., Ackerson, R. M., & Mauffrey, C. (2014).** Percutaneous fixation of anterior and posterior column acetabular fractures. Orthopedics, 37(10), 675-678.
3. **Chui, K. H., Chan, C. C. D., Ip, K. C., Lee, K. B., & Li, W. (2018).** Three-dimensional navigation-guided percutaneous screw fixation for nondisplaced and displaced pelvi-acetabular fractures in a major trauma centre. International Orthopaedics, 42, 1387-1395.
4. **Eckardt, H., Egger, A., Hasler, R. M., Zech, C. J., Vach, W., Suhm, N., ... & Saxer, F. (2017).** Good functional outcome in patients suffering fragility fractures of the pelvis treated with percutaneous screw stabilisation: assessment of complications and factors influencing failure. Injury, 48(12), 2717-2723.
5. **El-badawy, M. E. S., Mohamed, E. S. A. M., Alalfy, A. T., & El-aidy, S. M. (2020).** Outcome of Percutaneous Iliosacral Screw Fixation of Sacroiliac Joint Disruptions. The Egyptian Journal of Hospital Medicine, 78(2), 234-239.
6. **Fang, C., Alabdulrahman, H., & Pape, H. C. (2017).** Complications after percutaneous internal fixator for anterior pelvic ring injuries. International orthopaedics, 41, 1785-1790.
7. **Kolesnik, A. I., Lazarev, A. F., Solod, E. I., Ochkurenko, A. A., & Bukhtin, K. M. (2020).** Current trends in the surgical treatment of patients with pelvic and acetabular injuries (literature review). Genij Ortopedii, 26(2), 266-274
8. **Kusturova, A., & Kusturov, V. (2017).** TREATMENT OUTCOMES OF SEVERE PELVIC INJURIES IN POLYTRAUMA. In Травма 2017: мультидисциплинарный подход (pp. 3-4)

9. **Mansour, A., Givens, J., Whitaker, J. E., Carlson, J., & Hartley, B. (2022).** Immediate outcomes of early versus late definitive fixation of acetabular fractures: a narrative literature review. Injury.
10. **Navas, L., Mengis, N., Zimmerer, A., Rippke, J. N., Schmidt, S., Brunner, A., ... & Ulmar, B. (2022).** Patients with combined pelvic and spinal injuries have worse clinical and operative outcomes than patients with isolated pelvic injuries analysis of the German Pelvic Registry. BMC Musculoskeletal Disorders, 23(1), 251.
11. **Negrin, L. L., & Seligson, D. (2017).** Results of 167 consecutive cases of acetabular fractures using the Kocher-Langenbeck approach: a case series. Journal of orthopaedic surgery and research, 12, 1-8.
12. **Obey, M. R., Buesser, K. E., Hofer, E. L., & Miller, A. N. (2022).** Effect of Percutaneous Posterior Pelvic Ring Reduction and Fixation on Patient-Reported Outcomes. Journal of orthopaedic trauma, 36, S17-S22.
13. **Qoreishi, M., Hosseinzadeh, H. R. S., & Safdari, F. (2019).** Clinical results of percutaneous fixation of pelvic and acetabular fractures: a minimally invasive internal fixation technique. Archives of Bone and Joint Surgery, 7(3), 284.
14. **Routt Jr, M. C., Kregor, P. J., Simonian, P. T., & Mayo, K. A. (1995).** Early results of percutaneous iliosacral screws placed with the patient in the supine position. Journal of orthopaedic trauma, 9(3), 207-214.
15. **Singh, A., Lim, A. S. M., Lau, B. P. H., & O'Neill, G. (2022).** Epidemiology of pelvic and acetabular fractures in a tertiary hospital in Singapore. Singapore medical journal, 63(7), 388-393.
16. **Tempelaere, C., Vincent, C., & Court, C. (2017).** Percutaneous posterior fixation for unstable pelvic ring fractures. Orthopaedics & Traumatology: Surgery & Research, 103(8), 1169-1171.
17. **Veerappa, L. A., Tippannavar, A., Goyal, T., & Purudappa, P. P. (2020).** A systematic review of combined pelvic and acetabular injuries. Journal of clinical orthopaedics and trauma, 11(6), 983-988.
18. **Zhao, J. X., Zhang, L. C., Su, X. Y., Zhao, Z., Zhao, Y. P., Sun, G. F., ... & Tang, P. F. (2018).** Early experience with reduction of unstable pelvic fracture using a computer-aided reduction frame. BioMed Research International, 2018.