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Original Article

Clinical outcomes of percutaneous screw fixation of acetabular fracture: A minimally invasive procedure

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الملخص

أهداف البحث: يعد اجراء الاختزال المفتوح مع التثبيت الداخلي بمثابة العلاج القياسي للكسور الحقية. تثبيت الكسور الحقية بالمسمار عن طريق الجلد هو اجراء جديد مرغوب فيه بسبب التشريح المعقد للحوض. في هذه الدراسة، هدفنا تقييم النتائج الوظيفية والحركية ومعدل الشفاء والتشوهات الوعائية العصبية البعيدة في المرضى الذين خضعوا لتثبيت الكسور باستخدام المسمار بالطريق الراجع عن طريق الجلد

طرق البحث: شملت دراستنا ٣٦ مريضا يعانون من الكسور الحقية ممن خضعوا للعلاج بطريقة تثبيت الكسور بالمسمار عن طريق الجلد وذلك خلال الفترة من يناير ٢٠١٦ الى يونيو٢٠٢١, منهم ١٨ حالة مصابة بالكسور الحقية في منطقة العمود الأمامي و٧ مصابين بالكسور الحقية على المستوى المستعرض و ١١ مصابين بالكسور الحقية المصاحبة منهم ٦ مصابين بكسور حقية على شكل حرف ت. تم وصف الخصائص والنتائج السريرية بالتكرار والنسب المئوية للمتغيرات الفئوية، والمتغيرات المستمرة كقيمة متوسط وانحراف معياري، وتم استخدام برنامج الحزمة الإحصائية للعلوم الاجتماعية للتحليل الإحصائي

النتائج: بلغ متوسط الوقت لاستعادة القدرة على الحركة الكاملة مع تحمل الوزن الكامل ١٢,٩ ±٤,٥ أسبوعا، بالإضافة الى حوالي ١١,١ ±٨,٢ لاختفاء الألم مع التئام الكسور بشكل مرض. ظهرت اقلية من المرضى بلغت ٨,٣٪ تعاني من تشوهات تؤثر على الجهاز الوعائي العصبي القاصي بالإضافة الى١١,١ ٪ من المرضى الذين عانوا من اختلال وظيفي جنسي. تم تقييم شدة الألم أيضا باستخدام مقياس تناظري بصري، وكان متوسط شدة الألم في اليومين الأول والثالث بعد الجراحة ٤±٤, ٢و ٣,٨ ±٦, ٢ على التوالي بينما بلغ متوسط شدة الألم قبل الخروج من المستشفى ١,٧ ±٢,٦

الاستنتاجات: يعد التثبيت بالمسمار عن طريق الجلد بديلا جراحيا آمنا وفعالا لمعظم الكسور الحقية

الكلمات المفتاحية: الكسر الحقي؛ كسر الحوض؛ التثبيت عن طريق الجلد

Abstract

Objective: Open reduction with internal fixation is the surgical intervention of choice for acetabular fractures (AFs). Percutaneous screw fixation for AFs is a new procedure that is desirable because of the complex anatomy of the pelvis. In this study, we aimed to assess the functional outcomes, mobility, healing, and distal neurovascular abnormalities in patients who underwent percutaneous retrograde screw fixation.

Methods: Our study included 36 patients with AFs treated with percutaneous screw fixation between January 2016 and June 2021. There were 18 cases with anterior column AF, 7 cases with transverse AF, and 11 cases with associated AF, 6 of which had a T-shaped AF. Frequencies and percentages were used to describe characteristics and clinical outcomes. Mean and standard deviation were used for continuous variables. SPSS version 23 (IBM Corporation, Armonk, NY, USA) was used for statistical analysis.

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Results: The average time to regain full mobility with full weight bearing was 12.9 ± 5.4 weeks, and approximately 11.1 ± 2.8 weeks was required for patients to be pain-free with satisfactory fracture healing. Only a minority (8.3%) of patients had abnormalities affecting the distal neurovascular system, and 11.1% experienced sexual dysfunction. Pain severity was assessed with a visual analogue scale. The average pain severity on the first and third post-operative days was 4 ± 2.4 and 3.8 ± 2.6, respectively. However, the average pain intensity before discharge was 1.7 ± 2.6.

Conclusion: Percutaneous screw fixation is the most efficient surgical choice for most pelvic/AFs.

Keywords: Acetabular fracture; Hip fracture; Non-invasive surgery; Pelvic fracture; Percutaneous fixation

Introduction

An acetabular fracture (AF) is a break in the socket portion of the ball-and-socket hip joint.[1] AF is associated with a high risk of morbidity and mortality, owing to substantial hemorrhage and injury to the internal organs.[2,3] In the United States, between 2000 and 2009, 24,059 patients had unstable pelvic ring fractures, with an in-hospital mortality rate of 8.3%.[3] Most of these fractures are caused by fragility fractures of the acetabulum or high-energy injuries. High-energy injuries are the most common cause of AFs and contribute to 3% of all fractures. These injuries usually affect young populations.[4,5] The fatality rate in these patients is as high as 13.4%, and more than half of these patients have other complications, such as disabilities and incapacitation.[5] Owing to the traumatic injury mechanisms in these patients, treatment of these fractures remains challenging and poses a major dilemma for most orthopedic surgeons. In contrast, fragility fractures of the acetabulum usually affect older populations, and are commonly associated with osteoporosis, hypocalcemia, vitamin D deficiency, and secondary hyperparathyroidism.[4]

The management of AFs is either non-operative or operative, depending on the type of fracture and the patient's status. Surgical management has better outcomes in terms of early ambulation and lower morbidity and mortality.[6] Open reduction with internal fixation (ORIF) is the surgical intervention of choice in most institutions; however, it has several post-operative complications, such as massive hemorrhage, deep venous thrombosis, neurovascular injuries, heterotopic ossification, and infection.[7–9] In contrast, closed reduction and percutaneous screw fixation has many advantages, such as early weight bearing ambulation, less blood loss, and lower rates of tissue injury and infection.[10–13] However, this procedure also has several disadvantages, including neurovascular injuries (incidence ranging from 0.5% to 7.7%),[14] internal organ injuries, screw misplacement (incidence ranging from 2% to 15%),[14] and screw fracture.[6] Additionally, this technique relies on frequent intraoperative fluoroscopy to determine the position of the guide wire and screw, thereby exposing patients and medical staff to large amounts of radiation.[5] Another disadvantage is that the pelvic-acetabular morphology varies in each individual, and the size and direction of the bone channels differ. For example, the incidence of variation in the S1 vertebral body has been reported to be high as 30–50%, thus further increasing the difficulty of safe screw placement.[15]

With advances in imaging techniques and instruments, minimally invasive fixation techniques have become a viable option in the treatment of AFs. Because of the lack of published literature in the KSA, our study aimed to assess the functional outcomes, mobility, healing, and distal neurovascular abnormalities after percutaneous screw fixation of AFs. Finally, we aimed to estimate the incidence of sexual disabilities and assess the visual analogue scale (VAS) for pain scoring after percutaneous screw fixation of the AFs as a secondary objective.

Materials and Methods

Data for all patients who underwent percutaneous screw fixation of AFs were accessed on the basis of the BEST-Care Health Information System and patient files at the King Abdulaziz Medical City in Riyadh, KSA. Data for all patients who underwent percutaneous screw fixation of AFs were obtained.

The research was conducted in the King Abdulaziz Medical City, Riyadh, KSA. All patients 14 years of age or older who underwent percutaneous acetabular fixation were included in this study. A total of 405 patients with pelvic fractures were included between January 2016 and June 2021, and 250 patients without AF were excluded. The following 119 patients were also excluded from the study: patients who had duplicate data (16), those who did not receive percutaneous screw fixation of AF (101), and those who died before receiving adequate treatment (2). A total of 36 patients were enrolled in the study (Figure 1).

Our institution does not have specific indications for percutaneous screw fixation of AFs. Percutaneous screw fixation is a novel procedure that has been recently developed worldwide.

Multiple imaging modalities (radiography and computed tomography) were used to diagnose the AFs with Judet and Letournel classification.[16]

The primary outcomes assessed in the study were as follows: 1) mobility, defined as the ability to fully bear weight; 2) healing, defined as the ability to bear weight without pain; and 3) neurovascular abnormalities in the limbs. Secondary assessments included the following: 1) Sexual dysfunction. 2) Pain, assessed with the VAS on the first and third post-operative days and before discharge, and compared with the VAS score obtained preoperatively. Moreover, we continued to follow patients' VAS scores in OPD at 6 and 12 weeks. The scale ranged from 0 (no pain) to 10 (the most intense pain ever felt by the patient). 3) Standard radiographic views were obtained preoperatively (Figures 2–7), on days 1 and 6, and at week 12th postoperatively (Figures 8–13).

Frequencies and percentages were used to describe patients' characteristics and clinical outcomes. Mean and standard deviation were used for continuous variables. SPSS version 23 (IBM Corporation, Armonk, NY, USA) was used for statistical analysis.

Surgical technique

All surgeries were performed by three orthopedic surgeons subspecializing in orthopedic trauma surgery (Khalid A Alsheikh, Abdullah M Alzahrani, and Ali S Alshehri) in one tertiary care center with the assistance of a surgeon in training (resident or fellow). The orthopedic surgeons performing these procedures had an average of 7 years of specialized trauma surgical experience.

All percutaneous screw fixations of AFs were performed in accordance with a standardized technique. After confirmation of the fracture type clinically and the use of an imaging modality, the amenability to percutaneous fixation was assessed, and patients were counseled on the benefits and risks, and consented to the technique being performed. The operative room setup contained the following:

- Radiolucent table
- C-arm for fluoroscopic imaging
- Pelvic screw set, size 3.5, or 4.5 or 6.5–7.3 inches (with appropriate size determined according to the preoperative CT measurement of the column's corridors)

Patients were generally placed in supine position or in some cases in prone position if open reduction of the posterior wall or columns was concomitantly needed. Draping was performed from the mid-abdomen to the proximal thighs, emphasizing free draping of the affected limb to ensure free mobility. A urinary Foley catheter was inserted, and prophylactic antibiotics were given either after induction or within 1 h after the start of the procedure.

Afterwards, pelvic X-rays were taken in three views. The first view was usually an AP view of the pelvis, central and aligned with spinous processes of the vertebra transecting the symphysis pubis, thus ensuring proper visualization of the ilium and proximal femur bilaterally. For anterior column (A.C.) anterograde screws, the most commonly inserted screws in our study, an obturator outlet oblique (O.O.) view was used to determine the starting point and the trajectory of the percutaneous A.C. screw. If a 3.5 screw was chosen, direct drilling was usually performed. Otherwise, a set wire was used for other cannulated screw sizes. After entry was established, and the hip joint was bypassed, the iliac inlet oblique (I.I.) view was assessed to confirm that the trajectory was not toward the true pelvis or anteriorly outside the pelvis. After bypassing of the fracture by an adequate distance (i.e., a minimum of three to five threads of the chosen screw), measurements were taken, and the screw was inserted. Confirmatory images (O.O.) and (I.I.) were acquired and saved.

Results

The age range of the patients was from 18 to 72 years, and 29 patients were men. The most common cause of AF in

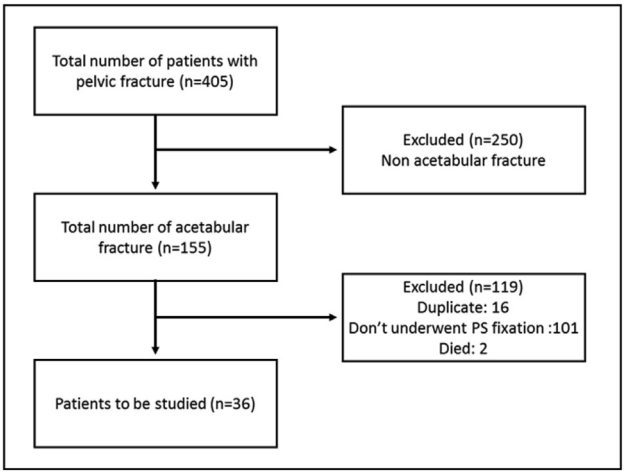

Figure 1: Study sample flow chart.

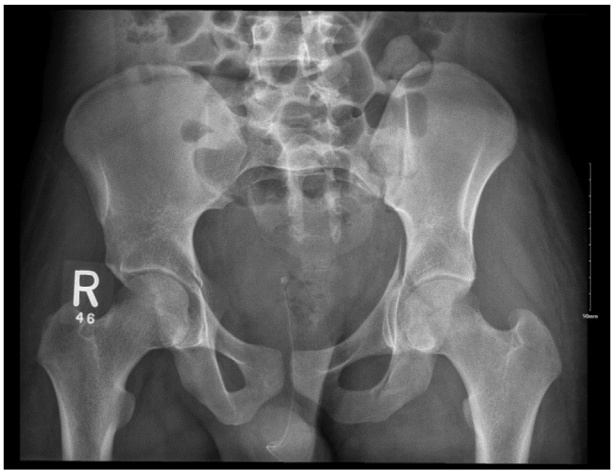

Figure 2: Anterior-posterior Judet view demonstrating bilateral AFs.

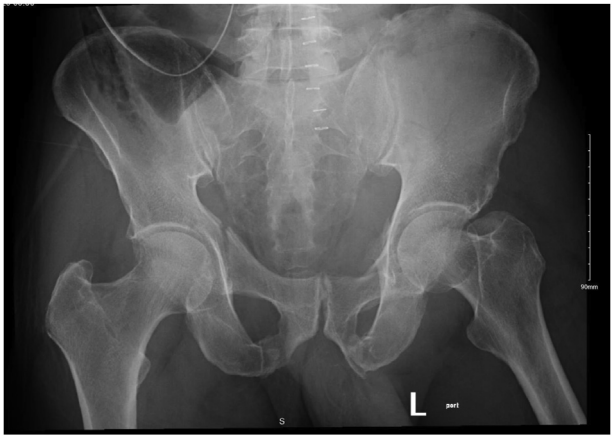

Figure 3: Anterior posterior view of the pelvis demonstrating multiple pelvic fractures involving the left iliac bone, superior and inferior pubic ramai bilaterally " saddle fracture" extending to the acetabulum, as well as right sacral fracture. Constituting lateral compression type 2 with extenstion to both acetabule.

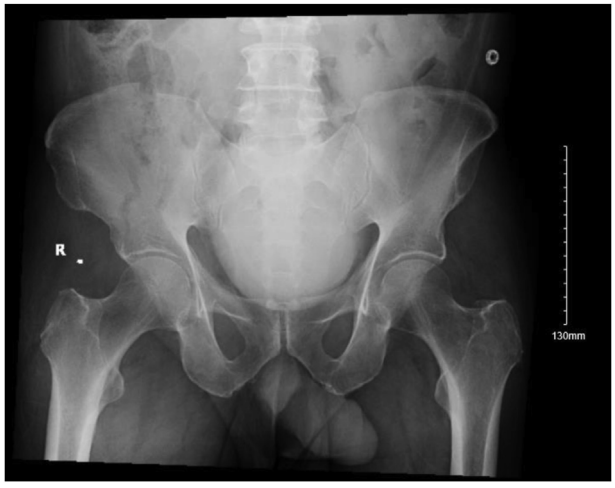

Figure 4: Anterior-posterior view demonstrating displaced fracture line in the right iliac bone extending to right acetabular anterior column.

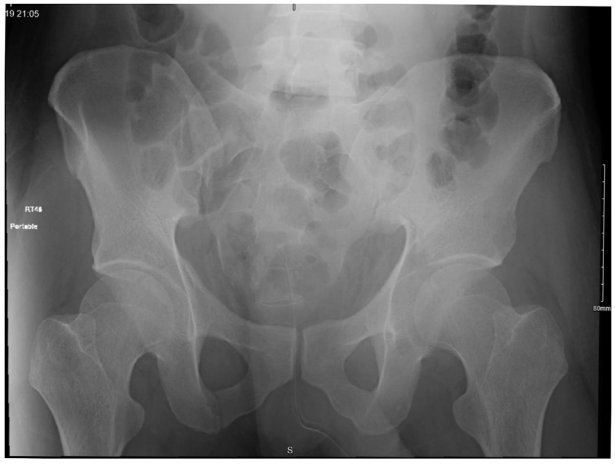

Figure 5: Anterior-posterior view demonstrating left high anterior column fracture and right sacral fracture .

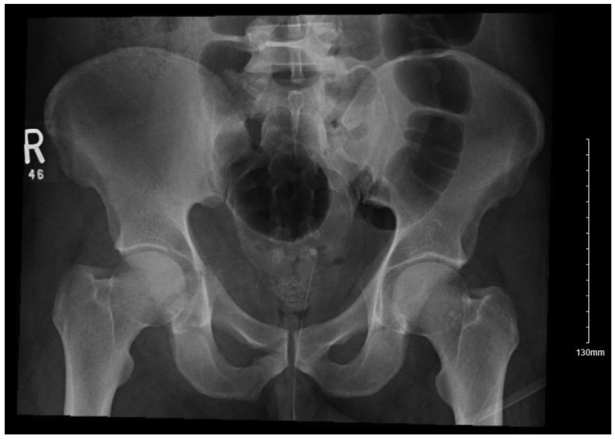

Figure 6: Anterior-posterior view demonstrating right transverse acetabulum fracture.

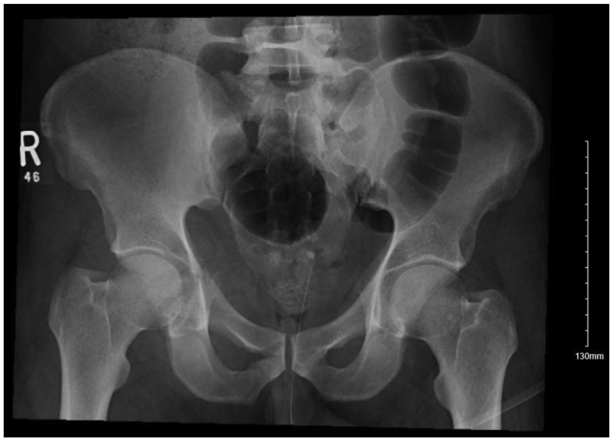

Figure 7: Anterior-posterior view demonstrating left acetabular transverse transtectal non-displaced fracture.

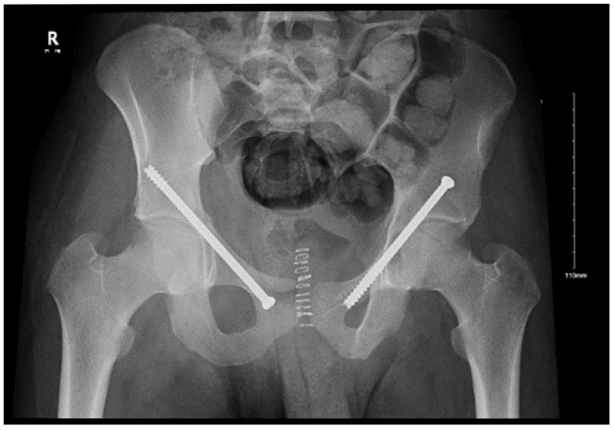

Figure 8: Anterior-posterior Judet view demonstrating bilateral acetabular screw fixation with anterograde and retrograde nailing.

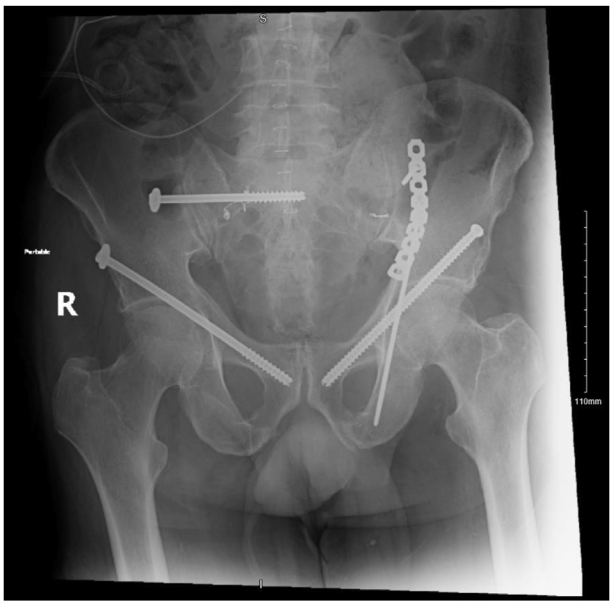

Figure 9: Anterior-posterior view demonstrating bilateral acetabulum anterior columns with antegrade screws, right sacroiliac joint and reconstructive plate along the left iliac bone extending to the superior with a left posterior column screw extending to ischium.

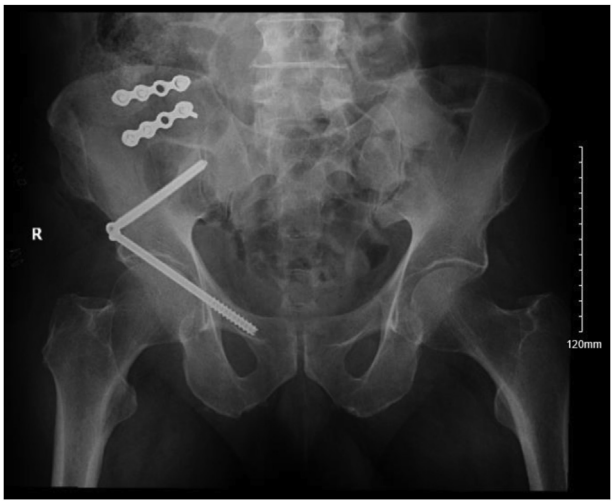

Figure 10: Anterior-posterior view demonstrating right acetabulum percutaneous antegrade anterior column screw and right lateral compression type 2 , percutaneous posterior column screw.

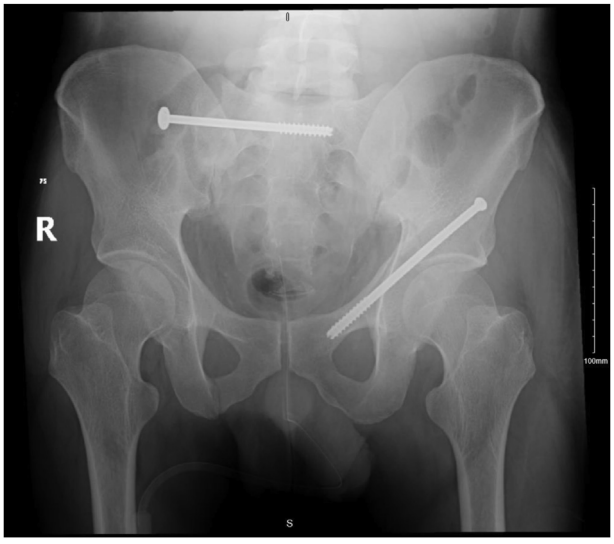

Figure 11: Anterior-posterior view demonstrating right sacral screw and left anterior column anterograde screw.

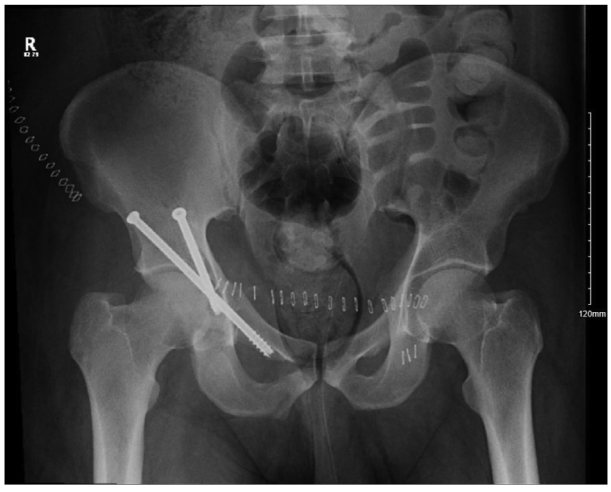

Figure 12: Anterior-posterior view demonstrating right anterior column percutaneous screw fixation Right open Posterior column screw fixation.

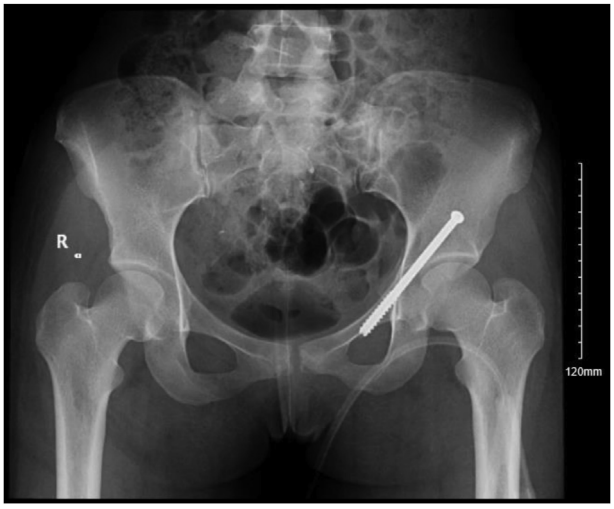

Figure 13: Anterior-posterior view demonstrating left anterior column anterograde percutaneous screw fixation.

these patients was motor vehicle accident (75%), followed by injury as a result of fall, being hit by a car, or being struck by a falling object (25%). According to Judet and Letournel classification,[16] 25 patients had elementary AFs; 18 patients had anterior column AFs, representing 50% of the study population; and 7 patients had transverse AFs. Eleven patients had associated AFs: six with T-shaped AFs and five with transverse AFs with posterior wall involvement. The average duration of hospital admission of all patients was 26.7 ± 24.4 days (Table 1).

The average time to regain walking ability with full weight bearing was 12.9 ± 5.4 weeks, and the time required for patients to be pain-free with satisfactory fracture healing was approximately 11.1 ± 2.8 weeks. Three patients (8.3%) had abnormalities affecting the distal neurovascular system, all of which were injuries sustained preoperatively, and 21 (58.3%) exhibited sexual dysfunction. The VAS was used to gauge the severity of pain among participants. The patients reported a

Table 1: Characteristics of patients with AF treated with percutaneous screw fixation.

	No.	36
Sex	Male	29 (80.6%)
	Female	7 (19.4%)
Age (y)		38.4 ± 19 (18−72)
Mechanism of injury	Motor vehicle accident	27 (75%)
	Falling	6 (16.7%)
	Pedestrian hit by a car	2 (5.6%)
	Hit by object fall	1 (2.8%)
Type of fracture	Transverse	7 (19.4%)
	T-shaped	6 (16.7%)
	Anterior column	18 (50%)
	Transverse with posterior wall	5 (13.9)
Duration of hospital admission (d)		26.7 ± 24.4 (5−143)
Average operation time (min)		225

Table 2: Functional outcomes of patients who underwent percutaneous screw fixation of AF.

	No.	36
Mobility (w)		12.9 ± 5.4
Healing (w)		11.1 ± 2.8
Distal neurovascular abnormalities	Intact	31 (86.1%)
	Non intact	3 (8.3%)
Sexual dysfunction	Intact	21 (58.3%)
	Non intact	4 (11.1%)
Visual analogue scale	First day post-operation	4 ± 2.4
	Third day post-operation	3.8 ± 2.6
	Discharge	1.7 ± 2.6

mean pain level of 2.71 pre-operatively, 4 ± 2.4 on the first post-operative day, 3.8 ± 2.6 2 days later, and 1.7 ± 2.6 before discharge (Table 2). On OPD follow up at 6 and 12 weeks, the mean pain level was 0.92 and 0.79, respectively. All patients had full hip range of motion immediately post-operatively, which was maintained after discharge.

Discussion

The focus of this study was on assessing the clinical outcomes of patients who underwent percutaneous screw fixation of AF, a minimally invasive procedure. We assessed the time required before full weight-bearing mobility without pain was achieved, alongside functional outcomes, healing, and distal neurovascular abnormalities. The average age of the study population was approximately 40 years, an age younger than those of the participants included in most previous studies, which averaged between 72 and 75 years.[17,18] Thus, age is an important risk factor for AFs, and our findings suggest that efforts to prevent AFs should be targeted at the factors that negatively influence bone density with age (e.g., osteoporosis).

The gold standard of intervention for AF stabilization has traditionally been ORIF.[2,19,20] Overall, this operation has satisfactory post-operative functional outcomes, but some concerns remain regarding the substantial risk of internal bleeding and other associated complications.[9,21–23] Consequently, standard management has undergone a major shift to percutaneous fixation, and many researchers have investigated its outcomes.[24,25] However, percutaneous fixation is a complicated procedure that requires expertise, owing to the complexity of the pelvic anatomical region and its surroundings.[25]

Because our study did not include a control group, we were unable to establish the superiority of percutaneous fixation over other treatment modalities (e.g., ORIF); however, Gary et al.[26] have reported that both treatments have the same functional outcomes in older individuals. Moreover, Swartman et al.[27] have found no differences between surgical approaches, but they have suggested that when ORIF is not warranted, such as when the degree of displacement is not large, a minimally invasive procedure, such as percutaneous fixation should be considered first.[26,27]

We observed that the average length of hospitalization for patients who underwent the percutaneous proximal fixation of AF was almost 1 month (24.2–26.7 days); however, hospital stays ranged from 5 to 143 days, thus indicating that complications could arise.

Most patients in our study were able to maintain full weight bearing and return to normal activities after approximately 12 weeks. Additionally, after an average of 11 weeks post-operatively, complete fracture healing was evidenced by full weight bearing without pain. A longer period of healing has been reported by Qoreishi et al., who have observed complete fracture healing with bone union 3 months post-operatively.[6]

In our study, post-operative pain intensity ranged from moderate to low, with VAS score averages of 4, 3.8, and 1.7 on days one and three, and at discharge, respectively. These scores were lower than those reported by previous studies. In one study, 10.3% of patients complained of chronic pain after percutaneous fixation; in contrast, Chui et al. have reported a mean pain intensity of 2.7 at 6 months after the operation.[11,28]

Only a small percentage of the patients included in our study experienced post-operative issues: three patients experienced distal limb anomalies in terms of neurovascular functions, and four patients experienced sexual dysfunction. A similar profile of neurovascular abnormalities has been observed in other studies, which have also found that some patients experience osteoarthritis of the proximal sacroiliac joint; therefore, longer periods of follow-up are recommended to monitor long-term complications more efficiently.[29,30]

Our study has several limitations. Owing to the loss of communication, we were unable to follow up with some patients, thus influencing the sample size. Another disadvantage was the absence of efficacy and clinical outcome comparisons with ORIF procedures, thus restricting the level of evidence provided by in this study. Nonetheless, our results provide a useful framework for future studies focusing on evaluating all possible techniques for treating AFs. Moreover, our study is the first of its kind in the region to thoroughly assess the percutaneous fixation method, including clinical use and outcomes.

Conclusion

Although the use of percutaneous AF repair in improving clinical outcomes and patient quality of life after treatment of AFs has been demonstrated, further research is required to establish its superiority to alternative procedures, such as ORIF, and to confirm the optimal surgical treatment for AFs.

Abbreviation: AF, acetabular fracture; ORIF, open reduction with internal fixation; VAS, visual analogue scale.

Source of funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors

Conflict of interest

The authors have no conflict of interest to declare.

Ethical approval

Ethical clearance was obtained from the King Abdullah International Medical Research Center in Riyadh on October 6, 2021. The study was not conducted until KAIMRC provided approval under approval number NRC21R/211/05.

Authors contributions

HSA, FAZ, and MIH contributed equally to this work; HSA, FAZ, KAS, AMZ, YSQ, and ASS contributed to the conception of the study; MIH, HSA and FAZ substantially contributed to literature search, data extraction, quality assessment, data analyses, and manuscript preparation; MIH contributed to improving the article for language and style and protocol preparation; MIH, HAS, YSQ, and FAZ helped perform the analysis with constructive discussions; KAS, AMZ, and ASS reviewed the manuscript and rewrote the final version. Approval of the final manuscript was obtained from all authors. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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