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Research Article

Evaluation of Functional Outcomes in Percutaneous Screw Fixation of Acetabular Column Fractures: A Prospective Observational Study

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Abstract: ***Introduction:*** Acetabular column fractures are challenging injuries traditionally managed with open reduction and internal fixation. Although open techniques achieve anatomical reduction, they are associated with substantial soft tissue dissection, blood loss, and postoperative morbidity. Percutaneous screw fixation has emerged as a minimally invasive alternative aimed at preserving soft tissues while maintaining fracture stability.**Aim:**To evaluate the functional outcomes of percutaneous screw fixation in acetabular column fractures using the Modified Merle d'Aubigné-Postel Score and to assess procedure-related complications.**Materials and Methods:**A prospective observational study was conducted in the Department of Orthopaedics, Pt. J.N.M. Medical College and Dr. B.R.A.M. Hospital, Raipur, between March 2024 and March 2026. Thirteen patients with acetabular column fractures underwent percutaneous screw fixation. Demographic characteristics, fracture patterns, operative parameters, complications, and functional outcomes were recorded. Functional assessment was performed using the Modified Merle d'Aubigné-Postel Score at 6 weeks, 3 months, and 6 months postoperatively.**Results:**The mean age of the patients was 42.5 ± 12.0 years. Females constituted 61.5% of the cohort. Anterior column fractures represented 69.2% of cases. Mean operative time was 51.5 ± 21.4 minutes, while mean blood loss was 28.1 ± 16.3 mL. Functional scores improved significantly from 14.3 ± 2.1 at 6 weeks to 16.3 ± 2.1 at 3 months and 17.2 ± 1.3 at 6 months ($p < 0.001$). At final follow-up, 61.5% of patients achieved excellent outcomes and 30.8% achieved good outcomes. Only one postoperative complication (7.7%) involving screw back-out was observed. **Conclusion:**Percutaneous screw fixation provides excellent functional recovery with minimal blood loss, short operative duration, and a low complication rate. The technique represents a safe and effective minimally invasive treatment option for selected acetabular column fractures.

Keywords: Acetabular fracture, Percutaneous fixation, Cannulated cancellous screw, Merle d'Aubigné score, Functional outcome

INTRODUCTION

Acetabular fractures represent some of the most complex injuries encountered in orthopaedic trauma practice. Their management remains challenging because of the intricate three-dimensional anatomy of the acetabulum, the requirement for precise articular reduction, and the high-energy mechanisms commonly responsible for these injuries. Judet, Judet, and Letournel revolutionized acetabular fracture management by introducing the column concept and establishing the foundation for modern classification and treatment strategies [1]. Subsequently, Letournel emphasized that restoration of joint congruity is the most important determinant of long-term hip function and prevention of post-traumatic arthritis [2].

Historically, open reduction and internal fixation (ORIF) became the standard treatment for displaced acetabular fractures because it allows direct visualization and anatomical reduction of fracture fragments [3,4]. However, extensive surgical approaches such as the ilioinguinal and Kocher-Langenbeck techniques are associated with considerable morbidity, including increased blood loss, prolonged operative duration, infection, heterotopic ossification, neurovascular injury, and delayed rehabilitation [7,17]. Meta-analytic evidence has demonstrated that complication rates increase significantly with extensive open approaches, particularly in elderly and polytrauma patients [17].

The pursuit of less invasive alternatives led to the development of percutaneous fixation techniques. Early studies by Gay et al. demonstrated the feasibility of CT-guided percutaneous fixation [5]. Routt and colleagues subsequently established reproducible fluoroscopic techniques and safe osseous corridors for anterior and posterior column screw placement [8,9]. Starr et al. further refined these methods and demonstrated

successful fixation of acetabular columns using minimally invasive screw trajectories [13].

Advances in fluoroscopic imaging, navigation systems, and understanding of pelvic anatomy have expanded the indications for percutaneous fixation. Several studies have reported reduced operative blood loss, shorter operative times, decreased soft tissue disruption, and faster postoperative recovery compared with conventional open surgery [22,25,33]. Recent systematic reviews have suggested that functional outcomes achieved through percutaneous fixation may be comparable to ORIF in carefully selected fracture patterns while significantly reducing surgical morbidity [33,37].

Despite increasing adoption of percutaneous fixation, evidence regarding functional outcomes in the Indian population remains limited. Differences in injury patterns, healthcare resources, patient demographics, and surgical expertise necessitate regional evaluation of treatment outcomes. Furthermore, there remains a need to assess whether the biological advantages of minimally invasive fixation translate into meaningful improvements in patient-reported functional recovery.
Therefore, the present study was undertaken to evaluate the functional outcomes of percutaneous screw fixation in acetabular column fractures using the Modified Merle d'Aubigné-Postel Score and to assess the safety profile of this minimally invasive technique.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational study was conducted in the Department of Orthopaedics, Pt. Jawahar Lal Nehru Memorial Medical College and Dr. Bhim Rao Ambedkar Memorial Hospital, Raipur, Chhattisgarh, India.

Study Duration

Patients were enrolled between March 2024 and March 2026 and followed for a minimum period of six months following surgery.

Sample Size

A total of 13 patients with acetabular column fractures meeting the eligibility criteria were included in the study.

Inclusion Criteria

• Patients with acetabular column fractures suitable for percutaneous fixation.
• Patients aged above 16 years.
• Patients willing to participate and provide informed consent.
• Fractures amenable to closed reduction and fluoroscopic fixation.

Exclusion Criteria

• Patients medically unfit for surgery.
• Fractures requiring formal open reduction and plating.
• Pathological fractures.
• Patients unwilling to participate or unable to complete follow-up.

Methodology

All patients underwent detailed clinical evaluation and radiological assessment using plain radiographs and three-dimensional computed tomography scans. Fractures were classified according to the Judet-Letournel classification system. Preoperative planning was performed to identify safe osseous corridors and determine the appropriate screw trajectory.

Surgical procedures were performed under fluoroscopic guidance. Depending on fracture configuration, anterior column, posterior column, or combined fixation strategies were employed using 6.5-mm cannulated cancellous screws. Both antegrade and retrograde techniques were utilized according to fracture morphology and corridor accessibility.

Postoperatively, patients underwent standardized rehabilitation protocols. Weight-bearing progression was guided by radiographic healing and clinical assessment. Functional evaluations were performed at 6 weeks, 3 months, and 6 months after surgery.

Outcome Measures

The primary outcome measure was functional recovery assessed using the Modified Merle d'Aubigné-Postel Score. Secondary outcome measures included operative time, intraoperative blood loss, time to full weight-bearing, and complications including infection, hardware failure, neurovascular injury, and reoperation.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using appropriate statistical methods. Continuous variables were expressed as mean ± standard deviation and categorical variables as frequency and percentage. Changes in Modified Merle d'Aubigné-Postel Scores over time were analyzed using repeated-measures analysis. A p-value less than 0.05 was considered statistically significant.

RESULTS

A total of 13 patients with acetabular column fractures underwent percutaneous screw fixation during the study period. Demographic characteristics, injury patterns, operative variables, functional outcomes, and complications were analyzed. Functional recovery was assessed using the Modified Merle d'Aubigné-Postel Score over a six-month follow-up period.

Demographic Characteristics

The study population had a mean age of 42.5 ± 12.0 years, with an age range of 17–65 years. Females constituted the majority of the cohort (61.5%), while males accounted for 38.5%. These findings indicate that percutaneous fixation was successfully applied across a broad adult age spectrum.

Table 1. Baseline Demographic Characteristics of the Study Population

Variable	Value
Total patients	13
Mean age (years)	42.5 ± 12.0
Age range (years)	17–65
Male	5 (38.5%)
Female	8 (61.5%)

Injury Characteristics

Falls and self-fall injuries represented the predominant mechanism of trauma, accounting for 69.2% of cases, whereas road traffic accidents constituted 30.8%. Right-sided injuries were substantially more common than left-sided injuries.

Table 2. Mechanism and Side of Injury

Variable	Frequency (%)
Mechanism of Injury	
Self-fall/Fall from height	9 (69.2%)
Road traffic accident	4 (30.8%)
Side of Injury	
Right	11 (84.6%)
Left	2 (15.4%)

The predominance of fall-related injuries suggests that low- to moderate-energy trauma constituted the major injury mechanism in this cohort. Right-sided acetabular fractures represented more than four-fifths of all injuries.

Fracture Pattern and Associated Injuries

Anterior column fractures constituted the most common fracture pattern. Associated injuries were present in more than half of the patients, reflecting the complex trauma burden associated with acetabular injuries.

Table 3. Fracture Classification and Associated Injuries

Variable	Frequency (%)
Anterior column fractures	9 (69.2%)
Associated fracture patterns	4 (30.8%)
Associated injuries present	7 (53.8%)
Isolated acetabular injury	6 (46.2%)

The predominance of anterior column fractures made these injuries particularly suitable for percutaneous screw fixation. More than half of the patients presented with additional skeletal trauma.

Operative Parameters

Percutaneous fixation demonstrated favorable intraoperative characteristics, including short operative duration and minimal blood loss. The average delay between injury and surgery was 7.5 days.

Table 4. Operative Characteristics

Variable	Mean ± SD
Delay to surgery (days)	7.5 ± 4.4
Operative time (minutes)	51.5 ± 21.4
Blood loss (mL)	28.1 ± 16.3

The minimally invasive nature of the procedure resulted in low intraoperative blood loss and efficient surgical times, supporting the feasibility of percutaneous fixation in selected acetabular fractures.

Percutaneous Fixation Techniques Utilized

Different screw trajectories were selected according to fracture configuration and osseous corridor availability. Retrograde anterior column fixation represented the most frequently employed method.

Table 5. Percutaneous Fixation Strategies

Technique	Frequency
Retrograde anterior column screw	6
Other anterior column fixation methods	4
Combined anterior and posterior column fixation	2
Bidirectional anterior column fixation	1

Total	13

Retrograde anterior column fixation was the preferred technique in most patients, while more complex fracture patterns required combined fixation strategies.

Functional Recovery Over Time

A progressive improvement in Modified Merle d'Aubigné-Postel scores was observed throughout follow-up. Statistical analysis demonstrated highly significant improvement in functional outcomes over time ($p < 0.001$).

Table 6. Progression of Modified Merle d'Aubigné-Postel Scores

Follow-up Period	Mean Score ± SD
6 weeks	14.3 ± 2.1
3 months	16.3 ± 2.1
6 months	17.2 ± 1.3
p-value	<0.001

Functional scores improved consistently between each follow-up period, indicating ongoing recovery in pain, gait, and hip mobility following percutaneous fixation.

Final Functional Outcome

At six months, the majority of patients achieved excellent or good functional outcomes. No patient remained in the poor functional category.

Table 7. Final Functional Outcome at 6 Months

Clinical Grade	Frequency (%)
Excellent	8 (61.5%)
Good	4 (30.8%)
Fair	1 (7.7%)
Poor	0 (0.0%)

A combined 92.3% of patients achieved good-to-excellent outcomes, demonstrating favorable functional recovery following minimally invasive fixation.

Weight-Bearing Recovery and Complications

The average time to full weight-bearing was approximately eleven weeks. The procedure demonstrated a favorable safety profile with only one postoperative complication.

Table 8. Recovery and Complications

Variable	Value
Time to full weight-bearing (weeks)	11.2 ± 3.0
Intraoperative complications	0 (0%)
Postoperative complications	1 (7.7%)
Screw back-out	1 (7.7%)
Deep infection	0
DVT	0
Nerve palsy	0

The absence of major neurovascular injuries, deep infections, or thromboembolic events highlights the safety of percutaneous fixation. Only one patient experienced screw back-out, which was managed successfully.

The present study demonstrated that percutaneous screw fixation of acetabular column fractures provided excellent functional outcomes with low morbidity. Significant improvement in Modified Merle d'Aubigné-Postel scores was observed over time, with 92.3% of patients achieving good or excellent results at six months. The technique was associated with minimal blood loss, short operative duration, rapid progression to full weight-bearing, and a very low complication rate.

DISCUSSION

The present prospective observational study evaluated the functional outcomes of percutaneous screw fixation in 13 patients with acetabular column fractures. The principal findings were significant improvement in functional scores over time, a high rate of good-to-excellent outcomes (92.3%), minimal intraoperative blood loss, short operative duration, early return to weight-bearing, and a low complication rate. These findings support the role of percutaneous fixation as a safe and effective minimally invasive treatment option for selected acetabular column fractures.

Demographic Profile and Injury Characteristics

The mean age of the study population was 42.5 years, with patients ranging from 17 to 65 years. Interestingly, females constituted 61.5% of the cohort. Traditionally, acetabular fractures have demonstrated a male

predominance because of their association with high-energy trauma. Sen et al. reported that 84.05% of acetabular fractures in India occurred in males, with the majority affecting young adults involved in road traffic accidents [1]. Similarly, Trikha et al. documented a predominance of young male patients in their epidemiological assessment of acetabular injuries [2].
The female predominance observed in the present study may be explained by the relatively higher proportion of fall-related injuries. Falls and self-fall injuries accounted for 69.2% of cases, whereas road traffic accidents constituted only 30.8%. This differs from the findings of Sen et al. and Trikha et al., where high-velocity road traffic trauma remained the leading mechanism of injury [1,2]. The variation likely reflects differences in patient selection and the inclusion of fracture patterns amenable to percutaneous fixation.

Anterior column fractures represented 69.2% of all cases and formed the largest fracture subgroup. This observation is consistent with the fact that anterior column fractures are particularly suitable for percutaneous screw fixation because of the availability of reproducible osseous corridors and fluoroscopic landmarks. AO Foundation recommendations similarly identify anterior column fractures among the most suitable indications for minimally invasive fixation techniques [3].

Operative Efficiency and Minimally Invasive Advantages

One of the most important findings of this study was the favorable operative profile associated with percutaneous fixation. The mean operative time was 51.5 minutes, while mean blood loss was only 28.1 mL. These findings highlight the minimal soft tissue disruption associated with the technique.

The results compare favorably with those reported by Ashour et al., whose systematic review demonstrated a mean operative time of approximately 43.4 minutes and average blood loss of 54.3 mL following percutaneous fixation [4]. Similarly, Parker and Copeland reported negligible blood loss and no wound-related complications following fluoroscopically guided fixation [5]. Dinesh et al. also observed significantly reduced operative duration and minimal hemorrhage compared with conventional open approaches [6].
In contrast, Giannoudis et al. reported substantially higher operative morbidity with open reduction and internal fixation, including greater blood loss, prolonged operative times, and increased complication rates [7]. The present findings therefore reinforce the biological advantages of minimally invasive fixation, particularly in patients who may not tolerate extensive surgical exposure.

The average delay to surgery in the present study was 7.5 days. This interval is comparable to many contemporary acetabular trauma series and allowed adequate preoperative planning using CT-based evaluation of fracture morphology and screw corridors.

Functional Recovery Following Percutaneous Fixation

The most significant finding of this study was the progressive improvement in Modified Merle d'Aubigné-Postel scores throughout follow-up. Mean scores increased from 14.3 at 6 weeks to 16.3 at 3 months and reached 17.2 at 6 months. Statistical analysis demonstrated highly significant functional improvement over time ($p < 0.001$).

These findings are consistent with previous reports evaluating minimally invasive fixation techniques. Gary et al. demonstrated favorable functional outcomes in elderly patients treated with minimally invasive reduction and percutaneous fixation, reporting restoration of mobility and satisfactory hip function [8]. Alsheikh et al. similarly reported excellent clinical recovery and low pain levels following percutaneous screw fixation, with most patients regaining full mobility within three months [9].

Dinesh et al. reported that more than 85% of patients achieved good-to-excellent outcomes using the Modified Merle d'Aubigné-Postel scoring system after percutaneous fixation [6]. Likewise, Gaur et al. observed excellent functional outcomes in 87.5% of patients undergoing fluoroscopy-guided anterior column fixation [10]. These findings closely parallel the present study, where 92.3% of patients achieved good or excellent outcomes at final follow-up.

The progressive improvement observed over six months indicates that fracture stability achieved through percutaneous fixation permits continued rehabilitation and restoration of hip function while minimizing the adverse effects of extensive surgical dissection.

Weight-Bearing Recovery and Rehabilitation

Early mobilization remains a major goal in acetabular fracture management. In the present study, patients achieved full weight-bearing at a mean of 11.2 weeks.
Kazemi and Archdeacon demonstrated that immediate full weight-bearing following percutaneous fixation of anterior column fractures did not result in secondary displacement, suggesting that intramedullary screw fixation provides substantial mechanical stability [11]. Mouhsine et al. reported successful mobilization within 24 hours and fracture union by approximately 12 weeks in elderly patients treated with retrograde screw fixation [12].

Similarly, Eckardt et al. found that early mobilization following percutaneous stabilization contributed to preservation of functional independence and improved long-term outcomes in fragility fractures [13]. The current findings support these observations and indicate

that minimally invasive fixation allows predictable progression toward functional recovery.

Safety Profile and Complications

The safety profile observed in the present study was highly favorable. No intraoperative complications occurred, and only one patient experienced postoperative screw back-out. There were no cases of deep infection, nerve palsy, thromboembolic events, or screw penetration into the hip joint.

These results compare favorably with previous reports. Bozzio et al. reported low complication rates and emphasized the soft tissue preservation achieved with percutaneous techniques [14]. Fang et al. noted that meticulous preoperative planning and careful guide-wire manipulation are essential for avoiding neurovascular injury during minimally invasive fixation [15].

The absence of major complications in the current study likely reflects careful patient selection, thorough preoperative CT evaluation, and strict adherence to established fluoroscopic corridors. Zwingmann et al. emphasized that screw accuracy is highly dependent on surgeon experience and imaging quality, regardless of the navigation system employed [16].

Compared with ORIF, which has been associated with infection, heterotopic ossification, wound complications, and neurovascular injury, percutaneous fixation substantially reduces the physiological burden of surgery while maintaining fracture stability [7].

Clinical Implications

The findings of the present study demonstrate that percutaneous screw fixation offers several clinically important advantages. The technique minimizes soft tissue trauma, reduces operative blood loss, shortens operative duration, permits early mobilization, and produces excellent functional outcomes. These benefits are particularly relevant in elderly patients, polytrauma patients, and individuals with significant medical comorbidities who may not tolerate extensive open procedures.

Furthermore, advances in fluoroscopic techniques, CT-based planning, and navigation technologies continue to improve the safety and reproducibility of percutaneous fixation. As surgeon familiarity increases, minimally invasive fixation may become an increasingly preferred option for appropriately selected acetabular column fractures.

Limitations

The present study has several limitations. The sample size was relatively small, limiting the statistical power of subgroup analyses. The follow-up period was limited to six months and therefore did not permit assessment of long-term outcomes such as post-traumatic arthritis or late implant-related complications. Additionally, the absence of a comparison group treated with open reduction and internal fixation precludes direct comparison between treatment modalities.

Despite these limitations, the study provides valuable prospective data supporting the effectiveness and safety of percutaneous fixation in acetabular column fractures.

CONCLUSION

Percutaneous screw fixation of acetabular column fractures produced excellent functional outcomes with a favorable safety profile in the present study. Significant improvement in Modified Merle d'Aubigné-Postel scores was observed throughout follow-up, with 92.3% of patients achieving good-to-excellent clinical outcomes at six months. The procedure was associated with minimal intraoperative blood loss, short operative duration, and low complication rates. Only one patient experienced postoperative screw back-out, while no cases of infection, neurovascular injury, or thromboembolic complications were encountered.

These findings support percutaneous fixation as a reliable minimally invasive treatment option for selected acetabular column fractures. Careful preoperative planning, accurate fluoroscopic guidance, and adherence to established osseous corridors are essential for achieving optimal outcomes. Larger comparative studies with longer follow-up are warranted to further define the long-term role of percutaneous fixation relative to conventional open reduction and internal fixation techniques.

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