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Functional and radiological outcomes of unstable acetabular fractures with or without quadrilateral plate involvement

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ABSTRACT

Background: Acetabular fractures are complex injuries that may result in poor hip function, arthritis, and long-term disability if not accurately reduced and fixed. Quadrilateral plate (QP) involvement increases fracture complexity and is often associated with medial femoral head displacement. Aim was to compare the functional and radiological outcomes of unstable acetabular fractures with and without QP involvement among surgically treated patients at NITOR, Dhaka.

Methods: This hospital-based comparative observational study was conducted in the Department of Orthopaedic Surgery, National Institute of Traumatology and Orthopaedic Rehabilitation, Dhaka, Bangladesh, from January 2024 to January 2026. Thirty patients with surgically treated unstable acetabular fractures were divided into two groups: with QP involvement (n=18) and without QP involvement (n=12). Demographic, clinical, radiological, operative, and follow-up data were analyzed using SPSS version 26.0, with $p<0.05$ considered significant.

Results: Patients with QP involvement had significantly more complex fracture patterns (p=0.012), greater preoperative displacement (8.4±2.7 mm vs 5.9±1.8 mm, p=0.008), and more frequent medial femoral head displacement (72.2% vs 16.7%, p=0.008). Operative duration (176.4±34.5 vs 142.5±28.7 minutes, p=0.008) and blood loss (780.0±210.0 vs 560.0±175.0 ml, p=0.005) were significantly higher. Excellent/good functional outcomes (61.1% vs 83.3%) and radiological outcomes (61.1% vs 83.4%) were lower, while complications were more frequent (38.9% vs 16.7%).

Conclusions: QP involvement was associated with greater fracture complexity, increased operative difficulty, and a trend toward poorer outcomes, highlighting the importance of meticulous preoperative planning, stable fixation, and close follow-up.

Keywords: Acetabular fracture, Quadrilateral plate, Functional outcome, Radiological outcome

INTRODUCTION

Acetabular fractures are uncommon but highly complex injuries because they involve the articular surface of the hip joint, where imperfect reduction may lead to chronic pain, stiffness, post-traumatic osteoarthritis, and long-term disability. Globally, fractures remain a major contributor to musculoskeletal morbidity; the Global Burden of Disease 2019 analysis estimated approximately 178 million new fracture cases in 2019, with a marked increase since 1990.[1]

Although acetabular fractures represent a small proportion of all fractures, they carry disproportionate clinical importance because they commonly result from high-energy trauma in young adults or low-energy trauma in elderly patients with osteoporotic bone.[2,3] Road traffic accidents are a major mechanism of pelvic and acetabular trauma, particularly in low- and middle-income countries where rapid motorization, unsafe road infrastructure, and limited trauma systems increase the severity of injury. A systematic review of musculoskeletal injuries in low- and lower-middle-income countries highlighted that pelvic and appendicular fractures impose a substantial burden, yet remain under-represented in trauma research.[2] In Bangladesh, road traffic injury is a major public health problem; a rural population-based study reported 80 fatal and 10,398 non-fatal road traffic injuries, with males and working-age adults being most affected.[4] These regional patterns are clinically relevant because acetabular fractures in young male patients often occur after high-energy mechanisms, requiring technically demanding operative management and prolonged rehabilitation. The QP is the medial wall of the acetabulum and plays a key role in maintaining hip congruity and preventing medial displacement of the femoral head. When acetabular fractures involve the QP, reduction becomes more difficult because fracture fragments may displace medially, the femoral head may migrate inward, and stable buttress fixation is required to restore the acetabular dome and columns.[5,6] Recent fracture-mapping and classification studies have emphasized that QP involvement is frequently associated with complex fracture patterns, including both-column, T-shaped, transverse, and anterior column with posterior hemitransverse fractures.[6,7] These patterns often require advanced surgical approaches, such as the modified Stoppa, anterior intrapelvic, pararectus, ilioinguinal, Kocher-Langenbeck, or combined approaches, depending on fracture morphology and the surgeon's expertise.[8,9] Clinical outcome after acetabular fracture fixation is strongly influenced by fracture pattern, timing of surgery, quality of reduction, stability of fixation, associated hip dislocation, sciatic nerve injury, marginal impaction, and postoperative complications.[10,11] Recent studies have reported satisfactory functional and radiological outcomes after anatomical reduction and stable fixation, but poorer outcomes remain more likely in complex fractures with quadrilateral surface involvement, medial displacement, and non-anatomical reduction.[8,10,12] Despite advances in imaging, implants, and surgical exposure, evidence remains limited regarding whether QP involvement independently worsens functional and radiological outcomes, especially in South Asian trauma settings. Most available studies are from high-volume international trauma centers, while local evidence from Bangladesh remains scarce. Differences in injury mechanism, referral delay, implant availability, surgical approach, rehabilitation access, and follow-up compliance may influence outcomes in this context. Therefore, aimed to compare the functional and radiological outcomes of unstable acetabular fractures with and without QP involvement among surgically treated patients at NITOR, Dhaka, Bangladesh.

METHODS

This hospital-based comparative observational study was conducted at Department of Orthopaedic Surgery, National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh, from January 2024 to January 2026, to evaluate the functional and radiological outcomes of unstable acetabular fractures with and without QP involvement. A total of 30 patients included were those aged 18 to 70 years with clinically and radiologically diagnosed unstable acetabular fractures, who underwent operative fixation at NITOR, had adequate preoperative radiological evaluation, and were available for postoperative clinical and radiological follow-up. Exclusion criteria included pathological fractures, old or neglected acetabular fractures, previous hip surgery or pre-existing advanced hip disease, associated femoral head or neck fracture affecting outcome assessment, severe polytrauma preventing follow-up evaluation, non-operative management, or incomplete medical records. Patients were divided into two groups based on QP involvement: 18 in the QP involvement group and 12 in the non- QP involvement group. Relevant demographic, clinical, radiological, operative, and follow-up data were collected using a structured data collection sheet. Baseline variables included age, sex, and residence. Injury-related variables included mode of injury, side involved, associated hip dislocation, and sciatic nerve injury. Fracture patterns were classified according to the Judet and Letournel classification. Preoperative radiological assessment included fracture displacement, medial displacement of the femoral head, marginal impaction, dome involvement, and intra-articular loose bodies. Operative variables included time from injury to surgery, surgical approach, duration of surgery, intraoperative blood loss, and the need for blood transfusion. All patients were treated surgically using appropriate approaches based on fracture morphology and surgeon's decision, including Kocher-Langenbeck, ilioinguinal, Modified Stoppa, or combined approaches. Postoperative patients were followed clinically and radiologically to assess functional outcome, radiological outcome, and complications. Functional and radiological outcomes were graded as excellent, good, fair, or poor. Postoperative complications, including wound infection, transient sciatic nerve palsy, heterotopic ossification, post-traumatic osteoarthritis, and need for reoperation, were recorded during follow-up. Data were analyzed using appropriate statistical methods using SPSS (v. 26.0). Continuous variables were expressed as mean±standard deviation, while categorical variables were presented as frequency and percentage. Comparisons between patients with and without QP involvement were performed using appropriate statistical tests. A p value of less than 0.05 was considered statistically significant.

RESULTS

The mean age was marginally higher in patients with QP involvement (39.6±11.8 years) compared to those without (36.8±10.5 years), though the difference was not statistically significant (p=0.510). Males predominated in both groups (77.8% vs 83.3%), while rural residency was more prevalent overall, especially in the QP group (66.7% vs 58.3%). The distribution of sex and residency did not differ significantly.

Road traffic accidents accounted for the majority of injuries in both groups, affecting 83.3% of patients in each group. Right acetabular fractures were slightly more common (55.6% in QP vs 58.3% in non-QP). Hip dislocation occurred in 27.8% of the QP group and 33.3% of the non-QP group. Sciatic nerve injury was present in 16.7% of patients in both groups. None of these differences reached statistical significance.

Fracture patterns differed significantly between groups (p=0.012). For QP involvement, both-column fractures (27.8%), transverse fractures (22.2%), and anterior column with posterior hemitransverse fractures (22.2%) were most prevalent. Posterior wall fractures predominated in non-QP cases (41.7%). Thus, QP involvement correlated with more complex fracture types.

QP involvement patients had significantly greater preoperative displacement (8.4±2.7 mm) than non-QP patients (5.9±1.8 mm; p=0.008). Medial femoral head displacement was also markedly more frequent in the QP group (72.2% vs 16.7%; p=0.008). Marginal impaction, dome involvement, and intra-articular loose bodies were similar between groups, with no statistically significant differences.

Operative complexity was greater in cases involving QP. Surgery duration was significantly longer in the QP group (176.4±34.5 minutes vs 142.5±28.7 minutes; p=0.008). Intraoperative blood loss was higher (780.0±210.0 ml vs 560.0±175.0 ml; p=0.005). Blood transfusion was more common among QP patients (66.7% vs 41.7%), though this was not statistically significant. The surgical approach varied significantly (p=0.014), with Modified Stoppa favoured for QP cases (44.4%) and Kocher-Langenbeck for non-QP cases (66.7%).

Excellent or good functional outcomes occurred in 61.1% of patients with QP involvement and in 83.3% of those without. Poor outcomes were confined to the QP group (11.1%). Functional results trended better in non-QP patients, but the difference was not statistically significant (p=0.454).

Excellent or good radiological outcomes were observed in 61.1% of patients with QP involvement and 83.4% without. Fair and poor outcomes occurred more frequently in the QP group (27.8% and 11.1%, respectively). The between-group difference did not reach statistical significance (p=0.451).

Complications were more frequent among patients with QP involvement. Any early postoperative complication occurred in 38.9% of QP cases compared with 16.7% of non-QP cases, though the difference was not statistically significant (p=0.249).

Superficial wound infection was seen in 16.7% vs 8.3%, heterotopic ossification in 22.2% vs 8.3%, and post-traumatic osteoarthritis in 22.2% vs 8.3%. Reoperation was required in 5.6% of patients with QP involvement only.

Table 1: Baseline characteristics of the study patients according to QP involvement.

Variables	With QP involvement, (n=18) (%)	Without QP involvement, (n=12) (%)	P value
Age (in years)	39.6±11.8	36.8±10.5	0.51
Sex			
Male	14 (77.8)	10 (83.3)	1
Female	4 (22.2)	2 (16.7)	
Residence			
Urban	6 (33.3)	5 (41.7)	0.716
Rural	12 (66.7)	7 (58.3)	

Table 2: Injury-related characteristics of the study patients according to QP involvement.

Variables	With QP involvement, (n=18) (%)	Without QP involvement, (n=12) (%)	P value
Mode of injury			
Road traffic accident	15 (83.3)	10 (83.3)	1
Fall from height	2 (11.1)	2 (16.7)	
Crush injury	1 (5.6)	0 (0.0)	
Side involved			
Right	10 (55.6)	7 (58.3)	1
Left	8 (44.4)	5 (41.7)	

Continued.

Variables	With QP involvement, (n=18) (%)	Without QP involvement, (n=12) (%)	P value
Associated hip dislocation			
Present	5 (27.8)	4 (33.3)	1
Absent	13 (72.2)	8 (66.7)	
Asso. sciatic nerve injury	3 (16.7)	2 (16.7)	1

Table 3: Distribution of fracture pattern according to Judet and Letournel classification.

Variables	With QP involvement, (n=18) (%)	Without QP involvement, (n=12) (%)	P value
Posterior wall	0 (0.0)	5 (41.7)	0.012
Posterior column	0 (0.0)	1 (8.3)	
Transverse	4 (22.2)	2 (16.7)	
T-shaped	3 (16.7)	1 (8.3)	
Both-column	5 (27.8)	0 (0.0)	
Anterior column with posterior hemitransverse	4 (22.2)	0 (0.0)	
Transverse with posterior wall	2 (11.1)	3 (25.0)	

Table 4: Preoperative radiological characteristics according to QP involvement.

Variables	With QP involvement (n=18) (%)	Without QP involvement (n=12) (%)	P value
Preoperative displacement (mm)	8.4±2.7	5.9±1.8	0.008
Medial displacement of femoral head	13 (72.2)	2 (16.7)	0.008
Marginal impaction	6 (33.3)	3 (25.0)	0.704
Dome involvement	8 (44.4)	4 (33.3)	0.709
Intra-articular loose body	4 (22.2)	3 (25.0)	1

Table 5: Operative characteristics according to QP involvement.

Variables	With QP involvement (n=18) (%)	Without QP involvement (n=12) (%)	P value
Time from injury to surgery (days)	8.2±3.0	7.1±2.5	0.31
Duration of surgery (minutes)	176.4±34.5	142.5±28.7	0.008
Intraoperative blood loss (ml)	780.0±210.0	560.0±175.0	0.005
Blood transfusion required	12 (66.7)	5 (41.7)	0.263
Surgical approach			
Kocher-Langenbeck	2 (11.1)	8 (66.7)	0.014
Ilioinguinal	3 (16.7)	1 (8.3)	
Modified Stoppa	8 (44.4)	1 (8.3)	
Combined approach	5 (27.8)	2 (16.7)	

Table 6: Functional outcome of the study patients according to QP involvement.

Functional outcomes	With QP involvement, (n=18) (%)	Without QP involvement, (n=12) (%)	P value
Excellent	3 (16.7)	4 (33.3)	0.454
Good	8 (44.4)	6 (50.0)	
Fair	5 (27.8)	2 (16.7)	
Poor	2 (11.1)	0 (0.0)	
Total	18 (100.0)	12 (100.0)	

Table 7: Radiological outcome of the study patients according to QP involvement.

Radiological outcomes	With QP involvement, (n=18) (%)	Without QP involvement, (n=12) (%)	P value
Excellent	4 (22.2)	5 (41.7)	0.451
Good	7 (38.9)	5 (41.7)	
Fair	5 (27.8)	2 (16.7)	
Poor	2 (11.1)	0 (0.0)	
Total	18 (100.0)	12 (100.0)	

Table 8: Postoperative and follow-up complications according to QP involvement.

Complications	With QP involvement, (n=18) (%)	Without QP involvement, (n=12) (%)	P value
Any early postoperative complication	7 (38.9)	2 (16.7)	0.249
Superficial wound infection	3 (16.7)	1 (8.3)	0.626
Deep infection	1 (5.6)	0 (0.0)	1
Transient sciatic nerve palsy	2 (11.1)	1 (8.3)	1
Heterotopic ossification	4 (22.2)	1 (8.3)	0.626
Post-traumatic osteoarthritis	4 (22.2)	1 (8.3)	0.626
Reoperation required	1 (5.6)	0 (0.0)	1

DISCUSSION

This study demonstrates that QP involvement in unstable acetabular fractures is associated with greater fracture complexity, more severe preoperative displacement, higher operative demand, and a trend toward poorer functional and radiological outcomes. For this study, patients were divided into two groups: those with QP involvement (QP group) and those without QP involvement (non-QP group). The two groups were broadly comparable in baseline characteristics, including age, sex, residence, mode of injury, side of injury, hip dislocation, and sciatic nerve injury; therefore, the observed differences are more likely related to fracture morphology than to demographic imbalance. Road traffic accident was the dominant mechanism in both groups, 83.3% each, which is consistent with reports from South Asian and other trauma-center series where acetabular fractures commonly affect young to middle-aged males following high-energy trauma.[1,13,14] The most important finding was the clear difference in fracture patterns between groups. In patients with QP involvement, both-column fractures (27.8%), transverse fractures (22.2%), and anterior column with posterior hemitransverse fractures (22.2%) were common, while posterior wall fracture was most common in the non-QP group (41.7%). This supports the idea that QP involvement is rarely an isolated injury but part of a complex acetabular disruption. Yang et al mapped 238 QP fractures and showed that QP fracture lines are closely linked with anterior column, transverse, T-type, and both-column configurations.[15] Similarly, Panella et al described QP injuries as frequent components of complex acetabular fractures, including both-column, T-shaped, transverse, and anterior column posterior hemitransverse patterns.[16] Wu et al also emphasized that QP fractures increase operative difficulty because of their deep location, thin medial wall, and association with medial femoral head displacement.[17] Preoperative radiological severity was greater in the QP group, with mean displacement significantly higher (8.4±2.7 mm versus 5.9±1.8 mm; p=0.008) and medial displacement of the femoral head more frequent (72.2% versus 16.7%; p=0.008). These findings indicate that medialization of the femoral head suggests failure of the medial acetabular buttress, requiring stable quadrilateral surface fixation. Previous studies have shown that various buttress and plating techniques help prevent secondary medial displacement and maintain hip congruity, underscoring the need for adequate fixation in these cases.[18,19] Surgery was more complex with QP involvement. Surgery lasted longer on average (176 minutes vs 142 minutes), and blood loss was greater (780 ml vs 560 ml). The Modified Stoppa approach was used more often in QP fractures (44.4%), while Kocher-Langenbeck was more common in non-QP fractures (66.7%). This matches the findings of Khoshabi et al, Jain et al, Al Adawy et al, Kilinc et al and Elmadag et al who reported that anterior intrapelvic or Modified Stoppa approaches provide better visualization of the QP, medial column, and pelvic brim, but require careful dissection and experience.[8,20-23] Scrivano et al also reported shorter operative time and less blood loss with the Modified Stoppa approach compared with ilioinguinal approaches in anterior acetabular fractures, suggesting that approach choice can affect surgical risks.[24] Functionally, excellent or good outcomes were seen in 61.1% of QP cases and 83.3% of non-QP cases, but this difference was not large enough to be considered certain. Radiological outcomes of excellent or good showed a similar pattern: 61.1% for QP cases and 83.4% for non-QP cases. The lack of certainty may be due to the small sample size, but the trend is still clinically meaningful. Shon et al reported excellent or good radiological outcomes in 87.9% of surgically treated acetabular fractures, with the quality of fracture reduction being a main determinant of outcome.[10] Wu et al reported excellent or good functional scores in 83.7% of elderly QP fractures after ORIF, but also showed that poorer reduction was linked to post-traumatic arthritis.[17] Ardiansyah et al similarly found that unstable acetabular fractures with QP involvement had worse functional and quality-of-life outcomes, reinforcing notion that QP involvement should be considered negative prognostic sign.[25] Complications were more common in QP group, including early problems after surgery (38.9% compared to 16.7%), superficial wound infection (16.7% compared to 8.3%), heterotopic ossification (22.2% compared to 8.3%), post-traumatic osteoarthritis (22.2% compared to 8.3%), and reoperation (5.6% compared to 0%). These findings agree with previous studies showing that complex acetabular fractures, residual displacement, medial wall fractures, and difficult surgical exposure increase risk of complications.[8,10,16,17] Clinically, findings support early CT-based fracture mapping, choosing the right anterior intrapelvic exposure when QP is involved, stable medial

buttress fixation, careful protection of nerves and blood vessels, and planned rehabilitation. In trauma settings with limited resources, recognizing QP involvement ahead of surgery can help surgeons plan for longer operations, higher blood loss, implant needs, and watch for hip arthritis, abnormal bone growth, and functional decline.

Limitations

This study was limited by its single-center design, small sample size, and relatively short follow-up period. Variation in surgical approach and fixation technique may have influenced outcomes. Long-term complications such as post-traumatic osteoarthritis, avascular necrosis, and late functional deterioration could not be fully evaluated.

CONCLUSION

This study concluded that unstable acetabular fractures with quadrilateral plate involvement showed more complex fracture patterns, greater preoperative displacement, more frequent medial femoral head displacement, longer operative time, and greater blood loss than fractures without quadrilateral plate involvement. Functional and radiological outcomes were poorer in the quadrilateral plate group, but the differences were not statistically significant. These findings suggest that quadrilateral plate involvement increases surgical complexity and may affect recovery, underscoring the need for thorough preoperative assessment, careful selection of surgical approach, stable medial buttress fixation, and close postoperative follow-up.

Recommendations

Careful preoperative CT-based assessment is recommended to identify quadrilateral plate involvement. These fractures should be managed with proper surgical planning, stable medial buttress fixation, and structured postoperative rehabilitation. Larger multicenter studies with longer follow-up are needed to confirm long-term outcomes.

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