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Functional Outcomes of Open Reduction and Internal Fixation of Comminuted Radial Head Fractures Using Low-Profile Minifragment Plates

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ABSTRACT

Background and Aim: Displaced comminuted radial head fractures may compromise elbow stability and forearm rotation. This study assessed early functional and radiographic outcomes after open reduction and internal fixation using low-profile minifragment plates. **Materials and Methods:** A prospective observational study was conducted in the Orthopedic Department, Ghurki Trust Teaching Hospital, Lahore, from August 2024 to February 2025. Seventy adults with Mason type III fractures or reconstructable Mason type IV fracture-dislocation underwent fixation using 2.0 to 2.4 mm minifragment plates. Outcomes at 12 weeks included Mayo Elbow Performance Score, range of motion, visual analogue scale pain, radiographic union, complications, and multivariable logistic regression for Mayo Elbow Performance Score below 80. **Results:** Mean age was 43.8 ± 15.2 years; 42 patients 60.0% were male. Mason type III occurred in 52 patients 74.3% and type IV in 18 patients 25.7%. Coronoid fractures were present in 18 patients 25.7% and ligamentous injuries in 12 patients 17.1%. Mean time to surgery was 4.2 ± 2.8 days and operative time 78.4 ± 22.6 minutes. Mean Mayo Elbow Performance Score was 89.3 ± 8.4 (median 91; range 68–100): excellent 48 68.6%, good 16 22.8%, fair or worse 6 8.6%. Flexion was 134.6 ± 9.2 degrees, extension deficit 6.8 ± 5.4 degrees, pronation 73.2 ± 11.4 degrees, and supination 72.8 ± 10.6 degrees. Mean pain score was 1.8 ± 1.5; pain 2 or less occurred in 56 80.0%, and functionally normal motion in 54 77.1%. Union by 12 weeks occurred in 66 94.3% with mean 8.4 ± 2.1 weeks; delayed union occurred in 4 5.7%. Complications occurred in 12 17.1%, including stiffness 4 5.7%, implant impingement 3 4.3%, fixation failure 2 2.9%, nonunion 1 1.4%, heterotopic ossification 7 10.0%, and reoperation 3 4.3%. Trends for Mayo Elbow Performance Score below 80 were observed with coronoid fracture (odds ratio 3.12; P = 0.129), ligament injury (odds ratio 4.16; P = 0.069), and type IV fractures (odds ratio 2.84; P = 0.149). **Conclusion:** Early outcomes after low-profile minifragment plating were favorable with high union rates and acceptable short-term morbidity.

INTRODUCTION

Radial head fractures represent a frequent intra-articular injury pattern of the elbow and account for a substantial proportion of adult elbow fractures. Restoration of painless forearm rotation and elbow stability is clinically relevant because the radial head contributes to load transmission across the radiocapitellar joint and provides secondary resistance to valgus and longitudinal instability in complex injury patterns. Mason's foundational classification, later modified in clinical practice, remains widely used to describe displacement and comminution and to guide operative decision-making, particularly in higher-grade fractures where mechanical block, instability, or articular incongruity is present [1]. Contemporary reviews continue to emphasize that surgical strategy should be individualized to fracture morphology, associated soft-tissue injury, and the feasibility of stable reconstruction [2].

Comminuted Mason type III and fracture-dislocation patterns are technically challenging because articular fragmentation, limited bone stock, and the need to respect the "safe zone" for implants increase the risk of loss of fixation, stiffness, and symptomatic hardware. Low-profile minifragment plates have been adopted to facilitate multi-fragment capture and buttressing while attempting to reduce implant prominence and radiocapitellar impingement [3,4]. Clinical series describing "on-table" or ex situ reconstruction commonly use low-profile mini-

plates to assemble fragments before definitive fixation, reporting favorable arcs of motion and high functional scores in selected patients [5,6]. Alternative low-profile configurations, including pre-contoured small plates adapted to the radial head, have also been evaluated, with comparable patient-reported outcomes and range of motion alongside signals for lower complication rates in some comparative designs [7]. Case-based evidence further supports mini T-shaped plate constructs for unstable radial head and neck injuries with excellent short-term functional scoring when early rehabilitation is achieved [7,8].

Despite these encouraging reports, published outcomes remain heterogeneous, and complication profiles appear sensitive to implant choice, fracture comminution, and associated ligamentous injury. Reported concerns include nonunion, implant failure, radio-ulnar or radiocapitellar impingement, and reoperation for implant removal, particularly when plate prominence or malediction compromises forearm rotation [9–11]. The present study is designed to evaluate functional outcome after radial head open reduction and internal fixation using low-profile minifragment plates, with structured assessment of elbow range of motion, validated functional scoring, radiographic union, and procedure-related complications, thereby providing clinically applicable outcome estimates for comminuted radial head fixation within a reproducible operative construct.

MATERIAL AND METHODS

A prospective observational study was conducted in the Department of Orthopedic and Spine Surgery, Ghurki Trust Teaching Hospital, Lahore, from August 2024 to February 2025. Consecutive adult patients presenting with displaced, comminuted radial head fractures considered suitable for reconstruction were screened. Fractures were classified on standard radiographs, and computed tomography was obtained when fragment mapping was required for operative planning. Eligible injuries included Mason type III fractures and selected Mason type IV fracture-dislocation patterns in which the radial head was deemed reconstructable after intraoperative assessment. Pathological fractures, open Gustilo grade III injuries, established infection, polytrauma requiring prolonged ventilation, and fractures requiring primary radial head arthroplasty were excluded. The institutional ethics approval was obtained, and written informed consent was taken before enrolment.

The sample size was calculated for estimation of the overall complication proportion after radial head open reduction and internal fixation using low-profile minifragment plates. With an anticipated complication rate of 20% based on published ORIF series for complex radial head injuries and an absolute precision of 10% at 95% confidence, the required sample was 62. After inflating by 10% for loss to follow-up, a target sample of 70 patients was set.

All procedures were performed under regional or general anaesthesia using a standard lateral elbow approach. Fragments were reduced anatomically under direct vision, provisionally stabilized with Kirschner wires as required, and definitively fixed with low-profile 2.0 to 2.4 mm minifragment plates and screws positioned within the safe zone to minimize radiocapitellar impingement. Associated ligament injuries and coronoid fractures, when present, were addressed according to stability after radial head fixation. Postoperatively, a short period of immobilization was used, followed by supervised early range-of-motion exercises; strengthening was initiated after radiographic signs of progression toward union.

The primary outcome was functional status at 12 weeks measured by the Mayo Elbow Performance Score. Secondary outcomes included elbow flexion-extension arc and forearm pronation-supination measured with a goniometer, pain on a 10-point visual analogue scale, radiographic union, and complications including stiffness requiring intervention, implant prominence or impingement, fixation failure, nonunion, heterotopic ossification, and reoperation. Data were analyzed using SPSS. Continuous variables were summarized as mean with standard deviation or median with interquartile range; categorical variables were summarized as frequencies and percentages.

RESULTS

The study patients comprised 42 males (60.0%) and 28 females (40.0%) with mean age 43.8 ± 15.2 years. Fracture classification revealed Mason type III in 52 patients (74.3%) and type IV fracture-dislocation in 18 patients (25.7%). Associated injuries included coronoid fractures in 18 patients (25.7%) and ligamentous injuries in 12 patients (17.1%). All procedures were completed using low-profile minifragment plates (2.0–2.4 mm systems), with mean operative time 78.4 ± 22.6 minutes. Perioperative details and baseline characteristics are presented in Table 1.

Table 1

Baseline Characteristics and Operative Details

Characteristic	Value
Age (years), mean ± SD	43.8 ± 15.2
Male sex, n (%)	42 (60.0)
Right-sided injury, n (%)	44 (62.9)
Mason type III, n (%)	52 (74.3)
Mason type IV, n (%)	18 (25.7)
Associated coronoid fracture, n (%)	18 (25.7)
Associated ligamentous injury, n (%)	12 (17.1)
Operative time (minutes), mean ± SD	78.4 ± 22.6
Time to surgery (days), mean ± SD	4.2 ± 2.8

The primary outcome measure, Mayo Elbow Performance Score at 12 weeks, demonstrated excellent functional recovery with mean score 89.3 ± 8.4 (median 91; range 68–100). Excellent results (score ≥90) were achieved in 48 patients (68.6%), good results (80–89) in 16 patients (22.8%), and fair or lower (<80) in 6 patients (8.6%). Elbow flexion-extension arc revealed mean flexion 134.6 ± 9.2 degrees and mean extension deficit 6.8 ± 5.4 degrees. Forearm pronation measured 73.2 ± 11.4 degrees and supination 72.8 ± 10.6 degrees. Pain severity was low with mean Visual Analogue Scale score 1.8 ± 1.5, with 56 patients (80.0%) reporting pain ≤2. Functionally normal range of motion (flexion >130 degrees, extension deficit <10 degrees, pronation and supination >70 degrees each) was achieved in 54 patients (77.1%). Functional outcomes and range of motion are detailed in Table 2.

Table 2
Functional Outcomes and Range of Motion

Parameter	Mean ± SD (Range)
Mayo Elbow Performance Score	89.3 ± 8.4 (68–100)
Visual Analogue Scale pain	1.8 ± 1.5 (0–7)
Elbow flexion (degrees)	134.6 ± 9.2 (105–150)
Extension deficit (degrees)	6.8 ± 5.4 (0–22)
Forearm pronation (degrees)	73.2 ± 11.4 (40–90)
Forearm supination (degrees)	72.8 ± 10.6 (45–90)
Combined pronation-supination (degrees)	146.0 ± 18.2 (100–180)
Patients with functionally normal motion, n (%)	54 (77.1)

Radiographic union was achieved in 66 of 70 patients (94.3%) by 12-week follow-up, with mean time to union 8.4 ± 2.1 weeks. Four patients (5.7%) demonstrated delayed union without lucency progression, three of which achieved union by 16-week assessment. Procedure-related complications occurred in 12 patients (17.1%), comprising major complications in 6 patients (8.6%): fixation failure in 2 patients (2.9%), nonunion in 1 patient (1.4%), and reoperation in 3 patients (4.3%); and minor complications in 6 patients (8.6%): stiffness requiring intervention in 4 patients (5.7%), implant prominence or impingement in 3 patients (4.3%), and heterotopic ossification in 7 patients (10.0%), of which 5 cases (71.4%) were Brooker grade I–II without functional impact. Multivariable logistic regression identified trend associations between suboptimal outcome (Mayo Elbow Performance Score <80) and presence of coronoid fracture (odds ratio 3.12; P = 0.129), ligamentous injury (odds ratio 4.16; P = 0.069), and fracture type IV (odds ratio 2.84; P = 0.149), although these did not achieve statistical significance. Age and time to surgery were not significantly associated with functional outcome. Union rates and complications are summarized in Table 3.

Table 3
Radiographic Union and Complications

Outcome	n (%)
Radiographic union by 12 weeks	66 (94.3)
Delayed union at 12 weeks	4 (5.7)
Time to union (weeks), mean ± SD	8.4 ± 2.1
Complications (any)	12 (17.1)
Stiffness requiring intervention	4 (5.7)
Implant prominence or impingement	3 (4.3)
Fixation failure	2 (2.9)
Nonunion	1 (1.4)
Heterotopic ossification	7 (10.0)
Reoperation	3 (4.3)

DISCUSSION

The present study evaluated short-term functional recovery and complication profile after open reduction and internal fixation of displaced, comminuted radial head fractures using low-profile minifragment plates. At 12 weeks, the mean Mayo Elbow Performance Score was 89.3 ± 8.4, with excellent or good results in 91.4% of patients, accompanied by low pain intensity (mean visual analogue scale 1.8 ± 1.5) and functionally normal motion in 77.1%. These findings support the premise that anatomical reconstruction with stable fixation can restore early elbow function in reconstructable Mason type III and selected type IV injuries, aligning with contemporary guidance that internal fixation remains appropriate when fragment restoration is feasible and elbow stability can be achieved through comprehensive management of associated injuries [12,13].

Functional results in the current series compare favorably with published reports describing on-table or ex situ reconstruction supplemented by low-profile plates. Businger et al. reported excellent long-term functional outcomes after on-table reconstruction with low-profile mini-plates in severely comminuted fractures, with very high Mayo Elbow Performance Index scores in a small series, indicating that carefully executed reconstruction can yield durable function despite fracture complexity [5]. Similarly, Kumar et al. described on-table reconstruction for Mason type III fractures using low-profile plates, achieving good to excellent functional ratings with minimal residual disability on patient-reported assessment, although the evidence was limited by sample size [6]. A broader perspective is provided by Ring et al., who reported that open reduction and internal fixation of radial head fractures can yield acceptable outcomes but is strongly influenced by comminution and associated instability, reinforcing the importance of careful case selection and stable construct design [8].

Range of motion recovery in this study was clinically meaningful, with mean elbow flexion 134.6 ± 9.2 degrees, extension deficit 6.8 ± 5.4 degrees, pronation 73.2 ± 11.4 degrees, and supination 72.8 ± 10.6 degrees. These values are consistent with series using mini-plate constructs those priorities stable fragment capture and early rehabilitation. In a comparative design, Yang et al. evaluated pre-curved metacarpal plates for Mason type II and III fractures and reported satisfactory outcomes comparable to conventional T-plates with fewer complications in the pre-curved plate group, supporting the potential advantage of low-profile plate geometry and reduced implant prominence [7]. Although fracture patterns and follow-up intervals differ across studies, the present motion profile compares favorably with the broader literature suggesting that stiffness remains a central determinant of early outcome after ORIF, particularly when injury complexity necessitates more extensive dissection or prolonged immobilization [14,15].

Radiographic union was achieved in 94.3% by 12 weeks with a mean time to union of 8.4 ± 2.1 weeks. This early union signal is reassuring in a construct that uses minifragment plates (2.0 to 2.4 mm) to stabilize multiple articular fragments, and it parallels union expectations in reconstructable injuries reported in observational ORIF series. However, fixation failure (2.9%) and nonunion (1.4%) were observed, reflecting recognized vulnerabilities of fixation in highly comminuted patterns where bone stock is limited and cyclic loading may lead to micromotion. Comparative evidence indicates that construct stability, fragment count, and associated injury burden strongly influence these risks. For example, recent comparative work examining plate osteosynthesis versus arthroplasty in complex Mason type III patterns has emphasized that plate fixation becomes progressively less reliable as fragment number increases, supporting a pragmatic threshold beyond which replacement may be

preferable [16]. This is also consistent with the broader principle that reconstruct ability, rather than Mason grade alone, should drive selection between fixation and replacement [6,7].

The overall complication rate in the present study was 17.1%, with reoperation in 4.3%. Stiffness requiring intervention occurred in 5.7%, implant prominence or impingement in 4.3%, heterotopic ossification in 10.0%, and major mechanical complications were uncommon. These frequencies are within the range reported for ORIF in comminuted radial head injuries, though direct comparison requires caution due to differences in fracture morphology, stability restoration strategy, and duration of follow-up. Importantly, meta-analytic evidence has repeatedly shown a higher complication signal after ORIF compared with radial head arthroplasty for Mason type III and IV patterns, even when functional scores may be similar in selected contexts. Elsenosy et al. reported, in a systematic review and meta-analysis, that arthroplasty tends to produce superior functional outcomes and fewer complications than ORIF in Mason type III and IV fractures, although included studies were heterogeneous and largely non-randomized [17]. De Mauro et al. similarly concluded that ORIF for Mason type III fractures demonstrates a higher risk of complications compared with arthroplasty in pooled analyses, reinforcing the need for judicious selection of fixation indications and meticulous surgical technique when preservation is attempted [18].

Comparative primary studies further contextualize these findings. Chen et al. conducted a prospective randomized comparison of radial head replacement versus ORIF in unstable multi-fragmented fractures and demonstrated superior stability-related outcomes for replacement in that setting, highlighting that reconstructive fixation may be disadvantaged when comminution and instability are pronounced [19]. Ruan et al. also compared internal fixation with prosthetic replacement for Mason type III fractures and reported better clinical performance with replacement in selected cases, again suggesting that preservation strategies must be targeted to favorable fracture biology and reconstructable fragment geometry [20]. At the same time, replacement introduces device-specific risks, including loosening, overstuffing, capitellar wear, and long-term degenerative sequelae, which remain clinically relevant in younger patients and in resource-limited follow-up contexts [21].

Multivariable modelling indicated non-significant trend associations between suboptimal function (Mayo Elbow Performance Score below 80) and the presence of coronoid fracture, ligamentous injury, and Mason type IV fracture-dislocation, a direction consistent with the recognized adverse prognostic influence of complex elbow instability patterns and their propensity for stiffness, heterotopic ossification, and persistent functional limitation. Within this context, the current findings suggest that low-profile minifragment plating can deliver favorable early recovery when reconstruction is feasible, stability is restored, and rehabilitation is initiated promptly. Clinically, the high early union and predominance of excellent or good outcomes support plating as a joint-preserving option, while implant prominence and impingement highlight the need for strict adherence to safe-zone positioning and intraoperative confirmation of smooth forearm rotation. Heterotopic ossification was frequent but commonly low grade. Strengths included prospective consecutive recruitment and standardized functional and radiographic assessment. Limitations included short follow-up, single-center observational design, and limited power for predictor analyses.

CONCLUSION

Low-profile minifragment plate fixation provided reliable early restoration of elbow function after reconstructable comminuted radial head fractures managed in a tertiary orthopedic setting. Anatomical reduction with stable fragment capture supported timely radiographic healing and facilitated rehabilitation with low residual pain. Procedure-related complications were observed but were generally manageable, and major mechanical failure was uncommon. Injury complexity, particularly fracture-dislocation patterns and associated coronoid or ligament injury, appeared to adversely influence recovery and warrants heightened attention to stability restoration and postoperative mobilization. Low-profile plating remains an appropriate joint-preserving option when reconstruction is feasible. Longer follow-up is required to define durability and arthritis.

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