

Original Research Article

Functional outcomes following volar locking plate fixation of AO/OTA 23-B3 volar Barton fractures: a prospective cohort study

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ABSTRACT

Background: Volar Barton fractures are unstable intra-articular fractures of the distal radius characterized by disruption of the volar rim and radiocarpal instability. Anatomical reduction and stable fixation are important to restore joint congruity, permit rehabilitation, and reduce the risk of persistent instability and post-traumatic dysfunction. Volar locking plate fixation provides angular stability and subchondral support and is widely used for unstable distal radius fracture patterns.

Methods: A prospective cohort study was conducted at a tertiary care teaching hospital between April 2024 and October 2025. Thirty adult patients with closed AO/OTA 23-B3 volar Barton fractures underwent open reduction and internal fixation using a volar locking plate through the modified Henry approach. Patients were followed for 12 months. Functional outcome was assessed using the Modified Mayo Wrist Score (MMWS), which evaluates pain, functional status, range of motion, and grip strength. Clinical and radiological union, postoperative complications, and serial functional recovery were recorded at predefined follow-up intervals.

Results: Thirty patients completed the study. The mean age was 41.6 ± 13.4 years and 23 patients (76.7%) were male. Radiological union was achieved in all patients without loss of reduction or implant failure. At 12 months, 20 patients (66.7%) had excellent MMWS outcomes, 7 (23.3%) had good outcomes, and 3 (10.0%) had fair outcomes; therefore, 90.0% achieved good-to-excellent functional results. Three patients (10.0%) developed superficial wound infection, all of which resolved with antibiotic therapy and local wound care.

Conclusions: Volar locking plate fixation was associated with reliable fracture union and progressive improvement in pain, wrist motion, grip strength, and patient satisfaction during the first postoperative year. The findings support volar locking plate fixation as an effective treatment option for unstable AO/OTA 23-B3 volar Barton fractures, while the absence of a comparison group limits conclusions regarding superiority over alternative treatments.

Keywords: AO/OTA 23-B3, Distal radius fracture, Functional outcome, Modified mayo wrist score, Volar Barton fracture, Volar locking plate

INTRODUCTION

Distal radius fractures are among the most common fractures encountered in orthopaedic practice. Intra-articular fracture patterns are clinically important because restoration of articular congruity and alignment influences subsequent wrist function. Volar Barton fractures are an uncommon but clinically important subtype characterized

by a shearing fracture of the volar articular rim of the distal radius with varying degrees of radiocarpal subluxation or dislocation.¹⁻³

The mechanism of injury varies with age and activity level, with high-energy trauma more commonly reported in younger adults and low-energy falls contributing to injuries in older patients. Failure to restore the volar

buttress and radiocarpal alignment may result in instability, altered load transmission, post-traumatic arthritis, pain, reduced grip strength, and functional disability.³

The goals of operative treatment are restoration of the articular surface, maintenance of radial length and alignment, stable fixation, and early rehabilitation. Traditional treatment methods included closed reduction and casting, Kirschner-wire fixation, external fixation, and non-locking buttress plating. Volar locking plates provide fixed-angle subchondral support and have become an important option for unstable intra-articular distal radius fractures.^{2,4-6}

Several clinical studies have reported favorable outcomes following volar plating of volar Barton fractures; however, the published literature remains heterogeneous with respect to fracture pattern, implant design, outcome measure, and duration of follow-up.⁷⁻¹³

Studies specifically restricted to isolated AO/OTA 23-B3 fractures are relatively limited, and prospective data from Indian tertiary-care settings remain less abundant than the broader distal radius fracture literature.⁷⁻¹³

The modified mayo wrist score (MMWS) incorporates pain, functional status, wrist motion, and grip strength and provides a composite measure of postoperative recovery. The present study therefore evaluated functional outcomes following volar locking plate fixation in a homogeneous cohort of AO/OTA 23-B3 volar Barton fractures treated at a tertiary referral centre.

Aim

To evaluate the functional outcomes of volar locking plate fixation in patients with AO/OTA 23-B3 volar Barton fractures.

Objectives

The objectives were to assess functional recovery using the Modified Mayo Wrist Score during one year of follow-up, determine the time to radiological union, evaluate postoperative complications, and assess recovery of wrist motion, grip strength, and patient satisfaction.

METHODS

Study design and setting

This prospective single-centre cohort study was conducted in the department of orthopedics, Siddhartha Medical College and Government General Hospital, Vijayawada, Andhra Pradesh, India, between April 2024 and October 2025. The institution is a tertiary referral centre managing a high volume of orthopedic trauma from urban and rural populations. The study was approved by the institutional ethics committee before commencement, and all

procedures were performed in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from every participant before enrolment.

Study population

Adult patients presenting with closed volar Barton fractures of the distal radius were prospectively screened and recruited consecutively when they fulfilled the predefined eligibility criteria. Patients were eligible if they were aged 18-70 years, had a closed AO/OTA 23-B3 volar Barton fracture, presented during the study period, underwent open reduction and internal fixation using a volar locking plate, and were able to provide informed consent and comply with follow-up. Patients were excluded if they had an open distal radius fracture, dorsal Barton fracture, associated neurovascular injury, previous fracture or surgery involving the ipsilateral wrist, pathological fracture, polytrauma preventing functional assessment, medical contraindication to surgery, or an inability or unwillingness to complete follow-up.

Sample size

Sample size estimation was performed using Epi Info™ version 7.2.5 based on the estimated prevalence of volar Barton fractures reported in previous institutional data. The minimum required sample size was calculated to be 23 patients at a 95% confidence level with a 5% margin of error. Thirty consecutive eligible patients were therefore enrolled to account for potential loss to follow-up. All 30 patients completed the 12-month follow-up.

Preoperative evaluation

All patients underwent standardized clinical evaluation including demographic characteristics, mechanism of injury, hand dominance, relevant comorbidities, and detailed neurovascular examination. Standard posteroanterior and lateral wrist radiographs were obtained, while computed tomography was performed when fracture morphology or intra-articular extension required further delineation for operative planning. Fractures were classified according to the AO/OTA classification system. Routine preoperative investigations included complete blood count, serum electrolytes, renal function tests, blood glucose, viral serology, and blood grouping with cross-matching, followed by anesthetic fitness assessment according to institutional protocols.

Surgical technique

All procedures were performed by experienced consultant orthopedic surgeons using a standardized operative protocol. Prophylactic intravenous antibiotics were administered approximately one hour before skin incision. Surgery was performed under regional anesthesia with the patient positioned supine on a radiolucent hand table, and a pneumatic tourniquet was applied to the upper arm. The

fracture was approached through the modified Henry approach. After identification and protection of the radial artery and flexor carpi radialis tendon, the pronator quadratus was elevated subperiosteally to expose the distal radius. Fracture fragments were anatomically reduced under direct visualization with fluoroscopic assistance, with temporary Kirschner-wire fixation when necessary. A precontoured fixed-angle volar locking plate was positioned proximal to the watershed line to minimize flexor tendon irritation. Distal locking screws were inserted to stabilize the articular fragments, followed by proximal cortical screw fixation. Intraoperative fluoroscopy was used to confirm reduction, plate position, screw length, restoration of radial height and volar tilt, and absence of intra-articular screw penetration. The pronator quadratus was repaired over the implant whenever feasible, followed by layered wound closure and sterile dressing.

Postoperative protocol

Finger mobilization was initiated on the first postoperative day. The wrist was immobilized in a volar splint for approximately two weeks until wound healing. After suture removal, supervised physiotherapy emphasizing progressive wrist range-of-motion exercises was commenced. Strengthening exercises were introduced after radiological evidence of fracture union. Clinical and radiographic assessments were performed at 6 weeks, 12 weeks, 6 months, 9 months, and 12 months.

Outcome measures

The primary outcome was functional recovery at final follow-up, assessed using the Modified Mayo Wrist Score. The MMWS comprises four equally weighted domains: pain, functional status, wrist range of motion, and grip strength. The total score ranges from 0 to 100, with scores of 90-100 interpreted as excellent, 80-89 as good, 65-79 as fair, and below 65 as poor. Secondary outcomes included time to radiological union, serial pain recovery, wrist range of motion, grip strength, patient satisfaction, and postoperative complications including infection, hardware failure, tendon irritation, median nerve symptoms, loss of reduction, complex regional pain syndrome, nonunion, and malunion.

Radiological assessment

Standard posteroanterior and lateral radiographs were obtained during follow-up. Radiological union was defined by bridging trabeculae across at least three cortices, disappearance of the fracture line, and absence of tenderness during clinical examination. Radiographs were independently reviewed by two orthopedic surgeons to reduce observer bias.

Statistical analysis

Data were entered into Microsoft Excel and analysed using Epi Info™ version 7.2.5. Continuous variables were summarized using mean±standard deviation or median with interquartile range according to data distribution, while categorical variables were summarized using frequencies and percentages. Normality was assessed using the Shapiro-Wilk test. Because the present analysis was primarily descriptive and no comparative treatment group was available, serial functional outcomes were presented as proportions across predefined follow-up intervals. No inferential between-group analysis was performed.

Ethical considerations

The study protocol received approval from the institutional ethics committee of Siddhartha Medical College before patient recruitment. All participants provided written informed consent. Patient confidentiality was maintained throughout the study, and data were anonymized before analysis.

RESULTS

Patient characteristics

Thirty patients with closed AO/OTA 23-B3 volar Barton fractures underwent open reduction and internal fixation using a volar locking plate and completed the 12-month follow-up. The mean age was 41.6±13.4 years (range, 18-70 years), and 23 patients (76.7%) were male. Baseline characteristics are summarized in Table 1.

Table 1: Baseline patient characteristics.

Variables	Value
Number of patients	30
Mean age (years)	41.6±13.4
Age range (years)	18-70
Male (%)	23 (76.7)
Female (%)	7 (23.3)

Fracture union

Radiological union was achieved in all 30 patients during follow-up. No patient developed nonunion, loss of reduction, or implant failure requiring revision surgery.

Serial clinical recovery

Pain, patient satisfaction, wrist range of motion, and grip strength demonstrated progressive recovery during follow-up. The principal serial findings are summarized in Table 2.

Table 2: Selected serial clinical recovery outcomes.

Outcomes	6 weeks	12 weeks	6 months	12 months
Complete pain relief	0%	16.7%	63.3%	83.3%
Complete patient satisfaction	0%	13.3%	56.7%	83.3%
Normal wrist motion	0%	36.7%	66.7%	83.3%
Normal grip strength	0%	13.3%	40.0%	56.7%

Functional outcome

At 12 months, 20 patients (66.7%) had excellent MMWS outcomes, 7 (23.3%) had good outcomes, and 3 (10.0%) had fair outcomes. No patient had a poor outcome. Overall, 27 patients (90.0%) achieved good-to-excellent functional results. The distribution is presented in Table 3.

Table 3: Modified mayo wrist score at 12 months.

MMWS outcome	N (%)
Excellent	20 (66.7)
Good	7 (23.3)
Fair	3 (10.0)
Poor	0

Postoperative complications

Three patients (10.0%) developed superficial wound infection. All infections resolved with antibiotic therapy and local wound care, and none required implant removal or revision surgery. No deep infection, tendon rupture, implant failure, nonunion, malunion, or complex regional pain syndrome was documented. Complications are summarized in Table 4.

Table 4: Postoperative complications.

Complications	N (%)
Superficial wound infection	3 (10.0)
Deep infection	0
Implant failure	0
Tendon rupture	0
Nonunion	0
Malunion	0
Complex regional pain syndrome	0

DISCUSSION

The present prospective cohort study evaluated a homogeneous group of patients with AO/OTA 23-B3 volar Barton fractures treated with volar locking plate fixation and followed for 12 months. The principal findings were complete radiological union in all patients, progressive recovery of pain, satisfaction, wrist motion, and grip strength, and a 90.0% good-to-excellent MMWS rate at one year. These findings are broadly consistent with previous reports of favorable outcomes after volar fixation of volar Barton fractures.⁷⁻¹⁶

The mean age in the present study was 41.6 years, and males accounted for 76.7% of the cohort. This pattern is comparable with several Indian series. Saini et al reported a mean age of approximately 42 years in 25 patients and a predominance of male patients, while Karthik and Ethiraj reported a mean age of 36.4 years with 75% male patients in their 40-patient prospective cohort. Saeed et al similarly reported male predominance in a 65-patient series.^{7,9,10}

The demographic similarity across these cohorts suggests that volar Barton fractures frequently affect relatively young and economically active adults. In this population, restoration of wrist function is clinically important because persistent stiffness, pain, or weakness may affect work and activities of daily living.

Radiological union was achieved in all patients without loss of reduction or implant failure. This result is comparable with previous reports in which union was achieved in all or nearly all patients treated with volar fixation. Saini et al reported favorable radiological outcomes without major complications, while Saeed et al reported successful fixation in all 65 patients. Tang et al also found complete fracture healing in their comparison of volar anatomical and locking plates.^{9,10,13}

The absence of loss of reduction in the present cohort may be related to the stability provided by fixed-angle distal fixation and careful restoration of the volar buttress. However, because radiological parameters such as radial height, radial inclination, volar tilt, and articular step-off were not quantitatively analysed in the present study, the relationship between anatomical restoration and functional outcome cannot be established from these data.

Pain recovery was progressive, with complete pain relief increasing from 0% at six weeks to 83.3% at 12 months. The gradual improvement is clinically plausible after an intra-articular fracture because postoperative pain, soft-tissue healing, stiffness, and rehabilitation influence early recovery. Previous studies of volar Barton fractures have also reported favorable pain and functional recovery following stable volar fixation.^{7,9,10}

Wrist motion improved progressively, with normal motion increasing from 0% at six weeks to 83.3% at one year. This pattern supports the functional rationale for stable fixation followed by structured rehabilitation. Karthik and Ethiraj reported favorable wrist motion at six months after variable-angle locking plate fixation, while Saini et al

reported satisfactory functional motion with early range-of-motion exercises.^{7,9,17,18}

Evidence from broader distal radius fracture populations also supports the role of early mobilization after stable volar plate fixation. Meta-analyses of randomized trials have demonstrated better short-term functional scores, grip strength, and some range-of-motion outcomes with early motion, with differences diminishing by later follow-up.¹⁷⁻¹⁹

In the present study, the wrist was protected in a volar splint for approximately two weeks before supervised wrist motion was initiated. The progressive recovery observed despite this short period of protection is consistent with the concept that stable fixation can permit rehabilitation without prolonged immobilization.

Grip strength recovered more slowly than wrist motion. Only 56.7% of patients had regained normal grip strength by 12 months, although the remaining patients had recovered 75-99% of the contralateral side. This pattern is consistent with the effects of postoperative disuse, pain, and gradual restoration of muscular conditioning. Huang et al. demonstrated that grip strength is an important component of functional recovery after fixation of marginal distal radius fractures, and Karthik and Ethiraj reported favorable functional recovery after variable-angle volar locking plate fixation.^{6,7}

The slower recovery of grip strength compared with wrist motion is clinically relevant because radiological union does not necessarily indicate complete functional recovery. Continued strengthening beyond the early rehabilitation period may therefore be important, particularly in patients with high functional demands.

The final MMWS results were favorable, with 66.7% of patients achieving excellent outcomes and 23.3%

achieving good outcomes. The overall good-to-excellent rate of 90.0% compares favorably with previous studies. Saini et al. reported 64% excellent and 32% good results, corresponding to a 96% good-to-excellent rate. Karthik and Ethiraj reported 65% excellent and 30% good results, while Saeed et al reported 73.8% excellent and 16.9% good results. Gundalli et al reported 80% excellent or good outcomes, and Pushadapu and Yaggadi reported 90% excellent or good outcomes.^{7,9-12}

The differences between studies should be interpreted cautiously because the outcome instruments, follow-up duration, fracture characteristics, implant designs, rehabilitation protocols, and patient populations were not identical. Nevertheless, the consistency of favorable functional outcomes across these series supports the effectiveness of stable volar fixation for this fracture pattern.

The complication rate in the present study was 10.0%, consisting exclusively of superficial wound infections that resolved without further surgery. Saeed et al reported superficial infection in 6.2% of patients together with wrist stiffness and carpal tunnel syndrome, while other series have reported generally low rates of major implant-related complications. Huang et al. emphasized that volar plate prominence and implant positioning remain relevant to flexor tendon complications, supporting the importance of careful plate placement.^{10,14,16}

The present protocol placed the plate proximal to the watershed line whenever fracture morphology permitted and included repair of the pronator quadratus when feasible. These technical measures may have contributed to the absence of tendon rupture in the present cohort, although the study was not designed to determine causality.^{14,15}

Table 5: Comparison of functional outcomes reported in selected studies.

Study	Year	Patients	Excellent/Good	Complication information
Huang et al ⁶	2022	42	Outcome measured with Mayo/DASH; not directly comparable	Implant-related tendon concerns reported
Karthik and Ethiraj ⁷	2022	40	95%	Not used for direct comparison
Pillai et al ⁸	2020	Not specified in manuscript	Good outcomes reported	Not specified
Saini et al ⁹	2021	25	96%	No major complications reported
Saeed et al ¹⁰	2025	65	90.7%	Superficial infection 6.2%; stiffness 4.6%; CTS 3.1%
Pushadapu and Yaggadi ¹¹	2025	20	90%	No major complication rate stated
Gundalli et al ¹²	2024	20	80%	Low/minimal complications reported
Present study	2026	30	90%	Superficial infection 10.0%; no major implant failure

Comparison with previous studies

The Table 5 summarizes the principal functional outcome findings reported in selected studies and the present cohort. Differences in outcome instruments and follow-up should be considered when interpreting cross-study comparisons.

Clinical interpretation

Taken together, the findings indicate that volar locking plate fixation can provide reliable union and favorable functional recovery in isolated AO/OTA 23-B3 volar Barton fractures when anatomical reduction, stable fixation, and structured rehabilitation are achieved. The 90% good-to-excellent functional rate is encouraging; however, the study design does not permit a conclusion that volar locking plates are superior to other fixation methods. The results should therefore be interpreted as supportive evidence for the effectiveness and feasibility of this treatment in a tertiary-care setting rather than evidence of comparative superiority.⁷⁻¹³

The strengths of the study include its prospective design, homogeneous inclusion of AO/OTA 23-B3 fractures, standardized operative technique, predefined follow-up intervals, complete 12-month retention, and serial assessment of pain, satisfaction, wrist motion, grip strength, and functional outcome. The study also provides prospective data from an Indian tertiary-care centre, where dedicated evidence for isolated volar Barton fractures remains relatively limited. The principal limitations are the single-centre design, small sample size of 30 patients, absence of a comparative treatment group, reliance on descriptive statistical analysis, and follow-up limited to 12 months. The study also did not include patient-reported measures such as DASH or PRWE and did not quantitatively analyse radiological parameters or predictors of functional outcome. The lack of a control group means that improvements cannot be attributed exclusively to the implant rather than to fracture healing and rehabilitation. Longer follow-up is also required to assess post-traumatic radiocarpal arthritis, late tendon problems, and other delayed complications.

Future research

Future multicentre prospective comparative studies should include larger cohorts, standardized radiological measurements, patient-reported outcome measures such as DASH or PRWE, and longer follow-up. Comparative evaluation of different volar plate designs and rehabilitation protocols would also help determine whether specific fixation strategies provide clinically meaningful advantages.¹⁷⁻¹⁹

Clinical relevance

Volar Barton fractures are unstable intra-articular injuries in which restoration of the volar buttress and radiocarpal alignment is central to functional recovery. In this prospective cohort, volar locking plate fixation was

associated with complete fracture union, progressive improvement in clinical parameters, and a 90% good-to-excellent MMWS rate at 12 months. The findings support its use as a practical fixation strategy for isolated AO/OTA 23-B3 fractures, particularly when stable fixation can facilitate a structured rehabilitation programme. The absence of a comparative group, however, limits any claim of superiority over other operative techniques.^{3,7-13}

CONCLUSION

Open reduction and internal fixation using a volar locking plate was associated with reliable fracture union and favorable functional recovery in this prospective cohort of AO/OTA 23-B3 volar Barton fractures. Pain, wrist motion, grip strength, and patient satisfaction improved progressively during the first postoperative year, and 90.0% of patients achieved good-to-excellent modified mayo wrist score outcomes at 12 months. Three patients developed superficial wound infection, all of which resolved without implant removal or revision surgery. Although these findings support volar locking plate fixation as an effective treatment strategy, larger comparative studies with longer follow-up are required before conclusions regarding comparative superiority can be made.

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