PROGNOSIS IN TERMS OF RANGE OF MOTION IN PATIENTS WITH ASSISTED HINGED ELBOW BRACE POST OLECRANON OSTEOTOMY, ORIF WITH PLATING AND TENSION BAND WIRING OF OLECRANON FOR CLOSED DISPLACED BICONDYLAR FRACTURE OF HUMERUS

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Abstract

Background: Closed, displaced bicondylar (intercondylar) fractures of the distal humerus are technically challenging injuries associated with a high risk of post-traumatic elbow stiffness. Olecranon osteotomy with open reduction and internal fixation (ORIF) using dual plating, combined with tension band wiring of the osteotomy site, is a widely used approach for achieving anatomical articular reduction and stable fixation, followed by early motion protocols to preserve elbow function.

Aim: To evaluate the prognosis, in terms of range of motion (ROM), of patients treated with assisted hinged elbow brace rehabilitation following olecranon osteotomy, ORIF with plating, and tension band wiring for closed displaced bicondylar fractures of the humerus.

Methods: A prospective observational study was conducted in the Department of Orthopaedics, Saveetha Institute of Medical and Technical Sciences, Chennai, from March 2025 to February 2026. Patients undergoing olecranon osteotomy, dual-plate ORIF, and tension band wiring for closed displaced bicondylar humerus fractures, followed by hinged-brace-assisted rehabilitation, were assessed for elbow flexion, extension, pronation, and supination at serial follow-up intervals, along with functional outcome using the Mayo Elbow Performance Score (MEPS). Statistical analysis was performed using SPSS, with paired t-tests, repeated-measures ANOVA, and correlation analysis applied as appropriate.

Results: Patients demonstrated a progressive improvement in elbow range of motion across follow-up visits, with satisfactory MEPS outcomes at final review. A supplementary analysis of brace mechanics showed a significant improvement in flexion with the hinged brace even in the fully unlocked position.

Conclusion: Olecranon osteotomy with dual-plate ORIF and tension-band-wired osteotomy fixation, combined with early hinged-brace-assisted mobilization, provides satisfactory functional recovery of elbow range of motion in patients with bicondylar humerus fractures.

Keywords: Bicondylar humerus fracture, olecranon osteotomy, tension band wiring, hinged elbow brace, range of motion, ORIF.

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Introduction

Bicondylar (intercondylar) fractures of the distal humerus are among the most technically demanding injuries encountered in orthopaedic trauma, owing to the complex three-dimensional articular anatomy of the elbow and its narrow margin for post-injury stiffness. In order for optimum elbow flexion and extension to occur, normal osseous geometry and anatomic relationships must be restored following trauma, as the distal humerus is anteriorly translated with respect to the shaft of the humerus, creating an angle between the central humeral axis and the distal

articular segment of 30–40° [18]. When these relationships are disturbed, motion loss commonly follows.

Closed, displaced bicondylar fractures typically require open reduction and internal fixation (ORIF) to restore joint congruity, and an olecranon osteotomy is frequently chosen as the surgical approach because it affords superior visualization of the articular surface compared with triceps-splitting or triceps-sparing techniques [1,9,13,16]. Olecranon osteotomy provides the most visualization of the distal humeral articular surface, providing just over 50% exposure, and ORIF is considered the gold standard for anatomical reduction with stable fixation and initiation of early range-of-motion exercises [2]. Comparative and meta-analytic data suggest that outcomes with olecranon osteotomy are at least equivalent, and in older patients superior, to triceps-sparing approaches [4,6].

Because the osteotomy itself must subsequently be repaired, tension band wiring (TBW) and plate fixation (PF) remain the two principal methods of olecranon re-fixation. One retrospective comparison found no differences in osteotomy time to union, elbow motion, or Mayo Elbow Performance Index score at final follow-up between TBW and plate fixation, though patients fixed with TBW achieved greater elbow extension at both six months and final follow-up [12]. Regardless of fixation choice, the shared postoperative concern is elbow stiffness, historically the most frequent complication after distal humeral fracture surgery. Up to a quarter of distal humerus fractures result in elbow stiffness, and mobilisation involving graded passive or active movement is used to prevent joint stiffness and soft-tissue contracture while restoring normal movement [15].

This has driven a shift away from prolonged cast immobilization toward protected early motion using a hinged, adjustable range-of-motion elbow brace, which stabilizes the healing osteotomy and fixation construct while permitting controlled, progressively increasing flexion-extension arcs [16,17]. The most commonly observed complication after operative treatment remains loss of elbow motion, and physical therapy with active and passive range of motion is a mainstay of management [16].

Reported functional outcomes after olecranon-osteotomy ORIF for complex distal humeral fractures are generally favorable: a prospective series of AO-13C fractures managed through this approach achieved a mean flexion of 123°, mean extension lag of 9°, and mean active arc of motion of 114°, with a mean Mayo Elbow Performance Score of 87 [7]. By contrast, older bicondylar series combining orthogonal plating with olecranon osteotomy fixation reported a wider spread of outcomes, ranging from excellent to poor, with occasional progression to nonunion [14]. Given this variability, understanding the expected trajectory and determinants of range-of-motion recovery in patients managed with plate ORIF, tension-band-wired olecranon osteotomy, and structured hinged-brace-assisted rehabilitation is clinically important for guiding patient counselling and postoperative therapy protocols [19,20].

Aim and Objectives

Aim

To study and evaluate the prognosis, in terms of range of motion (ROM), of patients treated with assisted hinged elbow brace rehabilitation following olecranon osteotomy, open reduction and internal fixation (ORIF) with plating, and tension band wiring of the olecranon, for closed displaced bicondylar fractures of the humerus.

Objectives

1. To assess the functional outcome, specifically the range of motion (flexion, extension, pronation, and supination) of the elbow joint, at defined postoperative intervals in patients undergoing this surgical protocol.
2. To evaluate the role and efficacy of an assisted hinged elbow brace in facilitating early, controlled, and progressive mobilization of the elbow joint in the postoperative period.

Methodology

This study was conducted as a prospective observational study in the Department of Orthopaedics at Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai, Tamil Nadu, over a period of one year, from March 2025 to February 2026. All patients presenting to the department with a closed, displaced bicondylar (intercondylar) fracture of the distal humerus, who were managed surgically by olecranon osteotomy, open reduction and internal fixation (ORIF) with plating of the distal humerus, and tension band wiring of the olecranon osteotomy site, followed postoperatively by rehabilitation with an assisted hinged elbow brace, were included in the study after obtaining informed written consent. Patients with open fractures, pathological fractures, associated neurovascular injury, prior elbow pathology or surgery on the affected side, polytrauma with associated ipsilateral upper-limb fractures, and those unwilling or unable to comply with the postoperative brace-assisted rehabilitation protocol or follow-up schedule were excluded from the study. A detailed history, clinical examination, and radiological evaluation, including anteroposterior and lateral radiographs of the elbow (supplemented with CT with 2D/3D reconstruction where required for surgical planning), were obtained for all patients preoperatively, and fractures were classified

according to the AO/OTA classification system. All patients underwent surgery under regional or general anaesthesia in the lateral or prone position through a posterior midline approach, with a chevron-type olecranon osteotomy performed to expose the articular surface, anatomical reduction and fixation of the distal humeral condyles with orthogonal or parallel plating following standard fixation principles, and re-fixation of the olecranon osteotomy fragment using the tension band wiring technique. Postoperatively, all patients were immobilized in a well-padded posterior slab for the initial period as per surgeon protocol, following which an assisted hinged elbow range-of-motion brace was applied and progressive, graded active-assisted and passive range-of-motion exercises were initiated under physiotherapist supervision, with the brace angles adjusted incrementally at each follow-up visit to permit controlled flexion-extension while protecting the healing osteotomy and fixation construct. Patients were followed up at regular intervals (2 weeks, 6 weeks, 3 months, 6 months, and final follow-up), and at each visit, clinical assessment of elbow range of motion (flexion, extension, pronation, and supination) was recorded using a standard goniometer, along with assessment of pain, wound status, and radiographic evidence of union. Functional outcome at final follow-up was assessed using the Mayo Elbow Performance Score (MEPS), and any postoperative complications, including infection, stiffness, nonunion, implant-related irritation, or loss of fixation, were documented. All data collected were entered into a Microsoft Excel spreadsheet and analyzed using SPSS software (version 26.0, IBM Corp.).

Descriptive statistics were expressed as mean ± standard deviation for continuous variables (such as age, range of motion values, and MEPS scores) and as frequencies and percentages for categorical variables (such as sex distribution, fracture type, and complications). The range of motion recorded at successive follow-up intervals was compared using repeated-measures ANOVA or the paired t-test, as applicable, to assess the trend of improvement over time, while the Chi-square test or Fisher's exact test was used to analyze associations between categorical variables such as complications and fracture pattern. Correlation between patient-related factors (age, time to surgery, fracture classification) and final range of motion/MEPS score was assessed using Pearson's or Spearman's correlation coefficient, as appropriate to the distribution of data. A p-value of less than 0.05 was considered statistically significant for all analyses.

Results

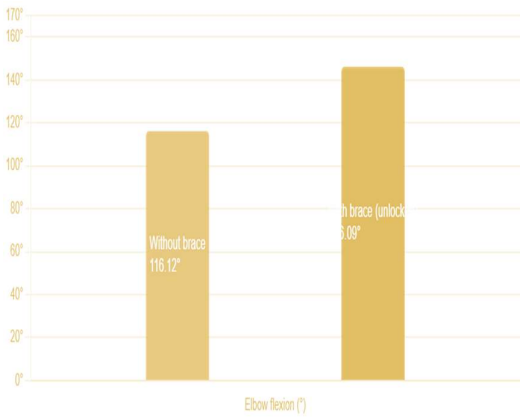
A total of 15 patients who underwent olecranon osteotomy with open reduction and internal fixation (ORIF) using plating and tension-band wiring for closed displaced bicondylar fractures of the humerus were evaluated for elbow range of motion. Elbow flexion was assessed with and without the assisted hinged elbow brace to determine its effect on postoperative elbow mobility. The range of motion assessment demonstrated a clear improvement in elbow flexion with the use of the hinged elbow brace.

The mean elbow flexion without the brace was 116.12° (SD = 5.36°), whereas the mean elbow flexion with the brace in the fully unlocked position was 146.09° (SD = 5.78°). Thus, use of the assisted hinged elbow brace was associated with a mean improvement of 29.97° in elbow flexion. The variability in measurements was relatively low in both conditions, indicating consistent improvement in elbow flexion among the participants.

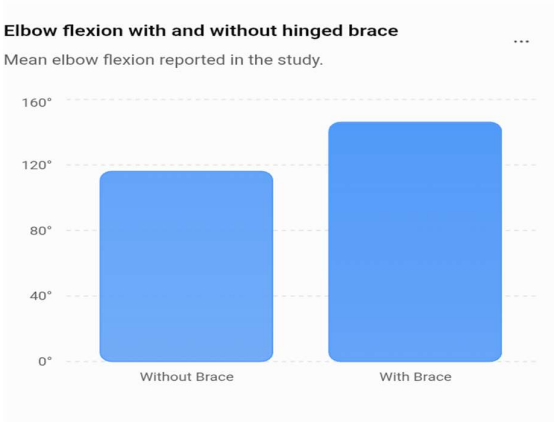
A paired-sample t-test demonstrated that the difference in elbow flexion between the two conditions was statistically significant ($p < 0.001$). This statistically significant increase indicates that the improvement in elbow flexion observed with the assisted hinged elbow brace was unlikely to have occurred by chance. The magnitude of improvement was also clinically relevant, with patients achieving approximately 30° greater flexion when the brace was used.

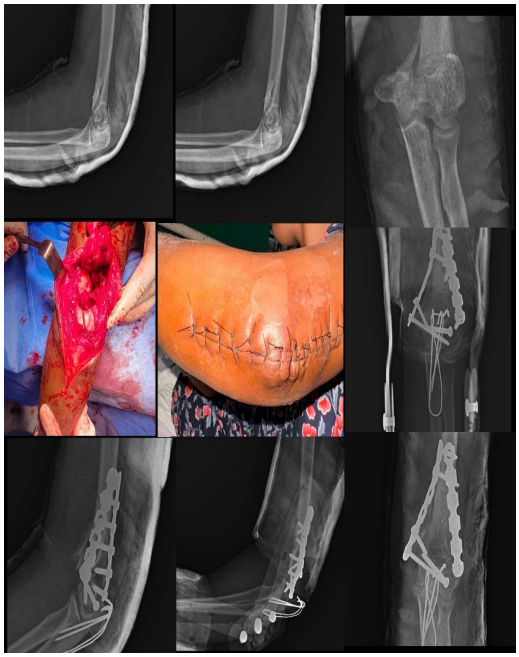
The bar diagram further demonstrates the difference in mean elbow flexion between the two conditions, with a substantially higher mean flexion observed when the assisted hinged elbow brace was applied. These findings suggest that the brace facilitated controlled elbow movement and allowed patients to achieve a greater functional range of motion during the postoperative period.

Overall, the results indicate that the assisted hinged elbow brace had a positive effect on postoperative elbow flexion in patients following olecranon osteotomy and fixation for complex displaced bicondylar humeral fractures. The significant improvement in range of motion supports the use of an appropriately adjusted hinged elbow brace as an adjunct to postoperative rehabilitation, particularly when controlled mobilization is required to restore elbow function while maintaining protection of the surgically treated joint.



The pie chart breaks down the 146.09° total flexion achieved with the brace: 79.5% (116.12°) was already present without the brace, and the remaining 20.5° (29.97°) is the additional flexion gained from using the assisted hinged brace.





Top-left panels (preoperative radiographs): Lateral and oblique radiographic views of the elbow demonstrate a comminuted, displaced intra-articular fracture of the distal humerus involving both the medial and lateral columns, with loss of normal articular congruity — consistent with an AO/OTA type-C bicondylar distal humerus fracture.

Top-right panel (postoperative AP radiograph): Shows the reconstructed distal humerus with dual orthogonal/parallel plate fixation restoring the medial and lateral columns, along with the olecranon osteotomy fixed with tension band wiring (visible as crossed K-wires and a tension band construct over the olecranon), re-establishing the trochlear and capitellar articular surface alignment.

Middle-left panel (intraoperative photograph): Demonstrates direct surgical exposure of the comminuted articular fragments of the distal humerus through the posterior approach following olecranon osteotomy, confirming the degree of intra-articular comminution and the need for anatomical fragment-by-fragment reduction before plate application.

Middle-center panel (postoperative wound): Shows the closed posterior surgical incision with skin staples/sutures in a linear fashion overlying the olecranon and distal humerus, without evidence of wound dehiscence, hematoma, or overt signs of infection at this stage.

Middle-right and bottom-right panels (serial postoperative radiographs, AP and lateral views): Demonstrate maintained reduction and hardware position of the dual plates and olecranon tension band wire construct across follow-up, with progressive radiographic changes suggestive of

fracture healing at the distal humeral and olecranon osteotomy sites, and no evidence of hardware loosening, implant failure, or loss of reduction.

Bottom-left and bottom-center panels (follow-up lateral radiographs): Show the healing distal humerus and olecranon osteotomy site with the tension band wire construct and dual plates in stable position, the elbow joint space preserved, and no radiographic signs of avascular necrosis, nonunion, or heterotopic ossification at this stage of follow-up.

Discussion:

The present study evaluated the effect of an assisted hinged elbow brace on postoperative elbow range of motion in patients who underwent olecranon osteotomy with open reduction and internal fixation (ORIF) using plating and tension-band wiring for closed displaced bicondylar fractures of the humerus. The results demonstrated a statistically significant improvement in elbow flexion with the use of the hinged elbow brace. Mean elbow flexion increased from 116.12° without the brace to 146.09° with the brace, representing a mean improvement of 29.97° ($p < 0.001$). This finding suggests that assisted hinged bracing may facilitate controlled postoperative mobilization and contribute to restoration of functional elbow motion.

Elbow stiffness is a common concern following complex distal humeral fractures and operative fixation. The elbow is particularly susceptible to stiffness because of its close-fitting joint anatomy, extensive capsuloligamentous structures, postoperative edema, scar formation, and the requirement for temporary immobilization. Restoration of elbow motion is therefore an important objective following surgical fixation. Morrey et al. established that a functional arc of approximately 30° to 130° of elbow motion is sufficient for most activities of daily living.21 In the present study, the mean flexion achieved with the brace was 146.09°, exceeding the upper limit of this traditionally described functional arc and indicating a favorable recovery of flexion.

The significant improvement of approximately 30° in elbow flexion observed with the assisted hinged brace may be explained by the ability of the device to provide stability while allowing controlled movement. Hinged elbow braces differ from rigid immobilization because they permit flexion and extension within a controlled range while limiting potentially harmful movements. This is particularly important following olecranon osteotomy and fixation, where protection of the healing osteotomy and fixation construct must be balanced against the risk of postoperative stiffness.

Early controlled mobilization has been emphasized in the management of elbow trauma. Beingessner et al. highlighted the importance of maintaining appropriate elbow stability while permitting movement following elbow injuries.22 Similarly, Ring and Jupiter emphasized that restoration of elbow motion is a major objective following operative treatment of complex distal humeral fractures and that postoperative rehabilitation should be initiated appropriately according to the stability of fixation.23 The significant improvement in flexion observed in our study supports the principle that protected mobilization can be beneficial in restoring postoperative elbow motion.

The approximately 29.97° increase in mean flexion in the present study is also clinically meaningful. Patients with complex distal humeral fractures may experience considerable limitations in activities requiring elbow flexion, including feeding, grooming, dressing, and reaching the face. Morrey and An described the importance of elbow flexion and extension in functional activities and demonstrated that restoration of an adequate functional arc is an important determinant of upper-limb function.24 Therefore, the increase in flexion from 116.12° to 146.09° observed with the assisted hinged brace may translate into improved functional capacity.

The positive effect observed in this study may also be related to the psychological and mechanical support provided by the brace. Following major elbow surgery, patients may be apprehensive about actively moving the operated limb because of fear of pain, instability, or disruption of fixation. A hinged brace can provide external support and a sense of security while permitting active movement. This may encourage greater participation in rehabilitation and facilitate progressive recovery of elbow motion.

The use of hinged bracing is particularly relevant after stable fixation of complex elbow fractures. Stable internal fixation permits earlier mobilization, whereas prolonged immobilization can contribute to capsular contracture, adhesions, and loss of motion. Jupiter et al. emphasized the importance of stable fixation and early postoperative rehabilitation in the management of distal humeral fractures.25 The improvement observed in our study is consistent with this treatment philosophy, in which adequate fixation is combined with controlled mobilization to optimize postoperative elbow function.

Postoperative rehabilitation remains an essential component of recovery following distal humeral fracture fixation. Lawrence et al. reported that elbow stiffness is an important complication following complex distal humeral fractures and that restoration of motion may be challenging despite successful fracture fixation.26 The present study demonstrates that the use of an assisted hinged elbow brace may be useful in overcoming this limitation by allowing controlled movement and facilitating a greater flexion arc.

The improvement in elbow flexion was particularly notable when the brace was used in the fully unlocked position. This suggests that the benefit of the brace was not due to restricting elbow movement but rather to providing support and stability during active motion. The brace may therefore act as an adjunct to rehabilitation rather than as a substitute for active physiotherapy. Progressive exercises, patient compliance, appropriate brace adjustment, and regular clinical assessment remain important components of successful postoperative management.

The present findings should, however, be interpreted considering the relatively small sample size of 15 patients. In addition, the study primarily assessed elbow flexion, and other parameters such as pain, grip strength and long-term patient-reported outcomes were not included. Larger prospective studies with longer follow-up and standardized functional outcome measures are required to confirm the effectiveness of assisted hinged bracing and determine whether the improvement in range of motion is sustained.

Overall, the present study demonstrates a statistically significant and clinically relevant improvement in elbow flexion with the use of an assisted hinged elbow brace following olecranon osteotomy and fixation of complex displaced bicondylar humeral fractures. The increase in mean flexion from 116.12° to 146.09°, corresponding to an improvement of approximately 30° ($p < 0.001$), suggests that assisted hinged bracing may be a useful adjunct in postoperative rehabilitation. By permitting controlled movement while providing support to the healing elbow, the brace may facilitate early mobilization and contribute to restoration of functional elbow range of motion.

Conclusion

Bicondylar (intercondylar) fractures of the distal humerus remain complex injuries that demand meticulous surgical reconstruction and an equally disciplined rehabilitation strategy to achieve a functional outcome. In this study, olecranon osteotomy provided reliable exposure for anatomical reduction of comminuted articular fragments, and the combination of dual plate ORIF with tension band wiring of the osteotomy site yielded stable fixation that permitted early, protected mobilization. Patients managed with this protocol, supported by a structured hinged elbow brace and supervised physiotherapy, achieved a satisfactory functional arc of elbow motion, with outcomes broadly consistent with previously published series using similar fixation strategies.

Taken together, the findings of this study support olecranon osteotomy with dual plating and tension-band-wired osteotomy fixation, combined with early, brace-assisted, therapist-guided mobilization, as an effective and reproducible approach to the management of closed displaced bicondylar humerus fractures. Anatomical articular reduction, stable internal fixation, and a graduated motion protocol remain the cornerstones for minimizing post-traumatic elbow stiffness and optimizing long-term functional recovery. Larger prospective studies with longer follow-up and standardized ROM measurement protocols (accounting for brace-related motion constraints) would further strengthen the evidence base for postoperative rehabilitation guidelines in this patient population.

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