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Metaphyseal Locking Compression Plate: A Reliable Solution for Distal Third Humerus Shaft Fractures Using a Posterior Approach for Appropriate Fracture Patterns

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Abstract

Background: Distal humerus fractures present significant challenges due to the low mineral density of metaphyseal bone, complex periarticular anatomy, and small distal fragment size, complicating stable fixation. This study aims to evaluate the effectiveness of the posterior approach with a metaphyseal locking compression plate (LCP) to address these challenges and improve fracture management outcomes.

Materials and Methods: This prospective single-center study evaluated the functional and radiological outcomes of metaphyseal LCP fixation using the posterior approach for extra-articular fractures of the distal third humeral shaft. Follow-ups evaluated range of motion, activity levels, fracture union, implant stability, and complications. The Mayo Elbow Performance Score MEPS and VAS Visual Analogue Scale measured functional outcomes.

Results: The study included 28 patients. The radiological union was achieved in all, with a mean union time of 13.28 weeks. At the final follow-up, the mean elbow range of motion (ROM) was 125.7°, with 12 patients exhibiting minimal elbow flexion contractures ranging from 5° to 15°. The mean MEPS score at six months was 85.9 (range 70-95). No non-union, malunion, implant failure, or deep infection were observed. Two patients had transient radial nerve palsy, which resolved within three months post-surgery.

Conclusions: Utilising a metaphyseal locking compression plate (LCP) with a posterior approach is both an effective and safe method for treating extra-articular fractures of the distal third humeral shaft. This technique provides stable fixation, enabling early mobilisation and achieving excellent functional outcomes.

Keywords: Distal third humerus shaft fracture; LCP metaphyseal plate; Posterior approach

Level of Evidence: IV

Introduction

Distal humerus fractures constitute approximately 2% of all fractures and exhibit a bimodal age distribution, with incidence peaks in young and older individuals [1-3]. In young adults, these fractures typically result from high-energy trauma, whereas in older people, they often result from low-energy falls [1,4]. Treating distal humerus fractures poses significant challenges due

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to osteopenic bone, complex anatomical structures, and the small size of distal fragments [2,5,6]. The primary goal of treatment is to secure proper alignment and stable fixation, enabling the early commencement of range of motion (ROM) exercises for the elbow joint. Achieving a painless, stable, and mobile elbow joint necessitates a systematic approach, including careful preoperative planning, adequate exposure, and stable fixation that permits early mobilisation [7].

While functional bracing is a viable option for humeral shaft injuries, it is not preferred for distal humerus fractures, where operative treatment remains the standard of care [8-13]. Open reduction and internal fixation have emerged as the management choice for treating distal humerus fractures [12,14]. The unique anatomy of the distal humerus, characterised by the transition from a round to a flat cross-section and a narrow medullary canal, makes locking intramedullary nails less viable for operative management [15].

Traditionally, humeral shaft fractures have been managed with a narrow 4.5 mm low-contact dynamic compression plate, ensuring the engagement of preferably eight cortices (four screws) on each side of the fracture or a minimum of six cortices (three screws) on each side [6,16,17]. A lag screw may also be used when feasible, particularly for spiral fracture patterns. However, achieving such fixation is challenging in distal humeral shaft fractures due to limited distal space, the curved configuration of the distal humerus when approached anteriorly, and the olecranon fossa posteriorly [6,17,18]. LCP (locking compression plate) metaphyseal plates offer several advantages, including versatility, limited contact design, stable fixation capabilities, and the staggered screw pattern that allows for the insertion of more screws within a small bone segment [19]. The posterior approach is preferred for plate placement. It offers direct visualisation and the option for double plating if needed while also highlighting its ease and familiarity [20].

This study aims to evaluate the clinical and radiological outcomes of metaphyseal locking compression plate (LCP) fixation via a posterior approach for distal third humeral shaft fractures. Specifically, it seeks to determine the effectiveness of LCP fixation in fracture healing and functional recovery while also analysing radiological results and assessing the feasibility of the posterior approach.

Material and Methods

A prospective study was undertaken at the Department of Orthopaedics, Maharaja Agrasen Hospital, New Delhi, to assess the functional and radiological outcomes of employing a metaphyseal locking compression plate (LCP) via a posterior approach for extra-articular fractures of the distal third humerus shaft. The study spanned from June 2019 to June 2020 and received approval from the institute's ethics committee, which adheres to the good clinical practice guidelines for clinical trials in India (Maharaja Agrasen Hospital Institutional Ethics Committee, registration number-ECR/745/Inst/DL/2015/RR-18). Based on the inclusion criteria, 28 patients who provided informed and written consent were enrolled in the study.

Inclusion Criteria:

1. Closed or open grade 1 Gustilo-Anderson distal third humerus shaft fractures.
2. Follow-up period of more than six months post-surgery.
3. Patients consented to participate in the study.
4. Patients aged over 18 years.

Exclusion Criteria:

1. Patients with pre-existing degenerative diseases of the elbow or shoulder joint.
2. Pathological or more than one-month-old fractures.
3. Combined elbow and shoulder fractures or floating elbow injuries.
4. Gustilo-Anderson grade 2 or 3 open fractures.
5. Previous surgery on the affected elbow and shoulder joint, or hemiparesis.
6. Patients who were unwilling to participate or unfit for surgery.

Implant Specifics: The metaphyseal plate features combi-holes for internal fixation using either standard screws or angular stable locking screws. This plate supports traditional screw fixation, including axial compression, as well as locking fixation for fixed-angle constructs., This plate is designed explicitly for distal third humeral shaft fractures; the plate includes at least four distal screw holes in a staggered pattern, allowing multiple screws to be placed in a small bone segment (Figure 1). Additionally, two distal holes are angled at 11° toward the centre of the plate for optimal locking screw application in the epiphyseal area [19].

Additional Design Features:

- The bullet nose plate tip facilitates minimally invasive surgical techniques.
- The limited contact design enhances periosteal vascularisation by reducing plate-to-bone contact.
- An elongated hole in the shaft aids fine-tuning reduction along the longitudinal axis.
- The distal portion of the plate has a thinner profile, making it easier to apply in the confined space of the distal humerus.

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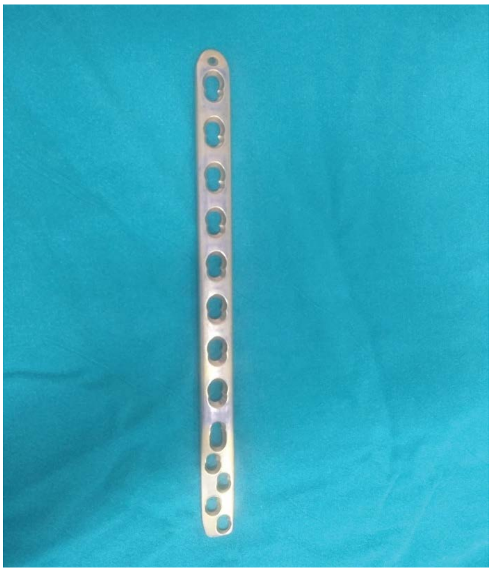

Figure 1: Metaphyseal LCP plate displaying a staggered screw pattern that allows four distal screws in a confined space for enhanced fixation stability.

Surgical Technique: To ensure unobstructed exposure of the radial nerve, the use of a tourniquet was avoided. The senior surgeon performed the surgeries within 3–7 days post-injury using a metaphyseal LCP plate (Synthes) with the posterior midline splitting approach described by Campbell and Hoppenfeld, involving a midline split through the triceps tendon [21,22]. Patients were positioned laterally with the elbow flexed on a well-padded bolster. Under general anaesthesia or brachial block, a longitudinal incision was made to the olecranon fossa from 8 cm below the acromion. The deep fascia was incised, and the interval between the long head and lateral head of the triceps was developed by blunt dissection. Distally, the medial head of the triceps was divided by sharp dissection along the skin incision line, and the muscle was stripped off the bone by epi-periosteal dissection. The radial nerve was identified and preserved. The fracture was reduced under direct vision and held with K-wires and bone-holding clamps, with a lag screw used if necessary. The LCP metaphyseal plate was fixed using 5.0 mm locking screws proximally and 3.5 mm locking screws distally, with additional interfragmentary screws as needed. Plate position and screw length were checked using an image intensifier, and intraoperative mechanical blockage of elbow flexion-extension was assessed. The wound was thoroughly washed and closed in layers over a suction drain, and an above elbow slab was applied for 10-14 days in selected cases.

Postoperative Protocol:

- Patients were advised to actively move their fingers and elevate the limb for 3-5 days.
- Intravenous antibiotics were administered for three days, and oral antibiotics for five days.
- Drain removal occurred after 48 hours, and sutures were removed on the 12th-14th postoperative day.
- A physiotherapist supervised initiating and continuing gentle passive and active-assisted ROM exercises for the elbow and shoulder.
- Patients were advised to refrain from lifting heavy weights until complete radiological union was achieved at the fracture site.

Follow-Up: Patients underwent regular clinical and radiological follow-ups in the outpatient department at two weeks, six weeks, three months, and every three months after that. Clinical evaluations assessed ROM and activity levels, while radiological assessments determined fracture union, non-union, secondary displacement, non-union, or other implant-related complications. Functional outcomes were determined using the Mayo Elbow Performance Score (MEPS) and the Visual Analogue Scale (VAS) for pain. The radiological union was defined as three cortex unions on orthogonal X-ray views.

Assessment Tools:

- **Mayo Elbow Performance Score (MEPS):** This score evaluates limitations caused by elbow pathology in daily activities using four subscales: pain, ROM, stability, and daily function [23]. The maximum score is 100 points.
- **Visual Analogue Scale (VAS):** This is a psychometric response scale for subjective pain measurement, in which patients indicate their pain level along a continuous line between two endpoints [24].

Results

This study included 28 patients with an age range of 20 to 68 years, averaging 40.07 years. The highest incidence was among individuals under 30, accounting for 10 cases (35.7%). Of the participants, 19 were male (67.9%) and nine were female (32.1%). Road traffic accidents were the primary cause in 19 cases (67.9%), with falls accounting for the remaining 9 cases (32.1%).

The average duration of surgery was 120.14 ± 11.12 minutes (range: 95-140 minutes). Average blood loss, measured via the surgical swab weighing technique, was 152.50 ± 32.28 ml (range: 110-220 ml) [25]. The mean follow-up duration was 9.07 months (6-12 months). No patients were lost to follow-up. The radiological union was achieved in an average of 13.28 weeks. At the final follow-up, the mean elbow range of motion (ROM) was 125.7° (range: 0°-140°), with a mean flexion of 128.9° (range: 110°-140°). Twelve patients exhibited minimal elbow flexion contracture (range: 5°-15°).

The most common complications encountered were elbow stiffness, radial nerve neuropraxia, and superficial infection. Specifically, there was one superficial infection, two radial nerve neuropraxia cases, and three stiffness cases. Functional outcomes evaluated using the Mayo Elbow Performance Score (MEPS) indicated that 11 patients (39.3%) had excellent results, 13 patients (46.4%) had good results, and four patients (14.3%) had fair results. At six months, the mean MEPS was 85.9 (70-95). The average Visual Analogue Scale (VAS) score for pain at six months was 0.964 (range: 0-3).

Elbow stiffness was primarily attributed to poor compliance with physiotherapy and mobilisation. While a stable construct aids early mobilisation, patient motivation and adherence to physiotherapy are crucial for optimal functional outcomes. Postoperative radial nerve neuropraxia occurred in 2 patients (7.1%), resolving entirely within three months. Antibiotic therapy successfully treated a case of superficial infection. All fractures united within the study period, with no cases of non-union or hardware prominence reported.

Discussion

Managing extra-articular distal third humerus fractures is challenging due to this region's complex anatomy and limited bone stock [2,5]. The primary objective is to achieve proper alignment with a stable construct to facilitate the elbow's early range of motion (ROM) [7]. Surgical intervention helps to facilitate early mobilisation and ensure predictable outcomes. However, these fractures present unique challenges, including short distal fragments and a narrow medullary canal, which reduce the suitability of intramedullary nailing [15]. While dual plating offers superior biomechanical strength, it requires more extensive soft tissue dissection, which can increase intraoperative time and blood loss [26]. Soft tissue preservation is crucial for fracture healing [27].

The torsional strength of a plate correlates with the number of screws used per segment [28]. Traditional locking compression plates (LCP), with uniformly sized screw holes, complicate the management of distal third humerus fractures due to the small distal fragment and restricted instrumentation space. To address these issues, we used an LCP metaphyseal plate that allows for insertion of at least four 3.5 mm screws into the distal fragment, achieving robust fixation with at least six cortices (Figures 2 and 3) [6,19]. The difficulties associated with contouring required for extra-articular distal humerus LCP plate, which can sometimes result in the opening of the opposite cortex, were not encountered with the metaphyseal LCP plate [29]. Furthermore, the metaphyseal LCP plate generally necessitates less extensive dissection than the extrarticular plate, which may contribute to improved clinical outcomes. This approach highlights the effectiveness of metaphyseal LCPs in managing distal third humeral shaft fractures. The results indicate that these implants offer enhanced stability in the complex metaphyseal region, where conventional plates might fall short, leading to fewer implant failures or non-union instances.

Figure 2: Case 1: 2A- Pre-operative AP and Lateral view of distal humerus fracture. 2B- Immediate postoperative AP and Lateral views showing fracture reduction and stabilization with a metaphyseal LCP plate and lag screw. 2C- Six-month postoperative AP and lateral views demonstrating fracture union and healing.

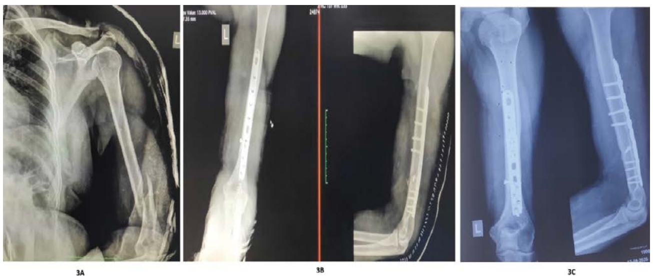

Figure 3: Case 2: 3A-Preoperative X-ray of a distal humerus fracture provisionally splinted with a 'U' slab. 3B- Immediate postoperative AP and lateral views of the distal humerus fracture. 3C- Twelve-month postoperative AP and lateral views showing well-healed distal humerus fracture.

Various surgical approaches are available for fixing distal humerus fractures, with the posterior approach being the most common. This approach, handy for more complex intra-articular fractures, has shown effective results in this series. We opted for the triceps-splitting approach due to its technical ease and advantages, including direct visualisation and optimal screw placement. This approach provides adequate exposure while minimising soft tissue damage, potentially enhancing fracture stability. The posterior approach also offers a suitable flat surface for plating and the option for double plating if necessary [30]. Our study showed excellent results using this approach.

Our results showed a mean radiological union time of 13.28 weeks, consistent with Kharbanda et al.'s [6] and Lee SK et al.'s [19] findings. Functional outcomes, assessed using Mayo elbow (MEPS), were categorised as excellent for 11 patients (39.3%), good for 13 patients (46.4%), and fair in four patients (14.3%), with an average MEPS of 85.9. These results are comparable to those reported by Trikha et al. [19], Dutta et al. [31], and Lee SK et al. [32]. Additionally, while Gupta et al. [14] reported a mean MEPS of 85 with 82.5% of patients achieving excellent or good results, our study

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found a mean range of motion of 125.7°, compared to 102° in their study [14]. The average VAS score at six months was 0.964 (range: 0-3), similar to the 0.745 (range: 0-4) reported by Dutta et al. [32] Outcomes tended to be slightly better in younger patients.

The complications reported in our study were Radial nerve neuropraxia in two patients, which resolved spontaneously in three months; one had Superficial infection resolved by antibiotics; and elbow stiffness in three patients, which improved with physiotherapy. Our series did not detect other common complications described with conventional implants, like non-union, implant loosening and implant cutting out. Dutta et al. [32] reported postoperative neuropraxia in two patients and plate failure in one patient. In contrast, the study by Trikha et al. [31] observed non-union in two patients (5.5%) but did not report any cases of superficial infection or implant failure. In our study, road traffic accidents (RTA) emerged as the predominant cause of injury, followed by falls. This finding is consistent with other research, identifying RTA and falls as the primary mechanisms of extra-articular distal humeral fractures. This case series demonstrates promising clinical outcomes using metaphyseal plates, including effective fracture healing, satisfactory functional recovery, and a lower incidence of complications. The findings suggest that metaphyseal plates can be an alternative to double plating and lateral column distal humerus plates *whenever the fracture pattern is suitable for metaphyseal plating.*

The study's statistical significance is constrained by its small sample size, which affects the reliability of the results. Moreover, the follow-up period may be insufficient for a complete evaluation of long-term outcomes and delayed complications. The absence of a control group also limits the ability to make direct comparisons. Future research should address these limitations by including larger sample sizes and extended follow-up periods to validate these findings and comprehensively understand long-term effects.

Conclusion

The LCP metaphyseal plate ensures stable fixation with its staggered 3.5 mm combination holes, allowing multiple screws in a small bone segment. The posterior approach facilitates radial nerve exploration and plate placement on the posterior surface, making it a practical option for distal third humeral shaft fractures. This case series demonstrates that combining this approach with advanced implant technology provides excellent fracture stability and functional recovery with minimal complications.

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