Functional Outcome of Perpendicular Plating Versus Parallel Plating In The Management Of Distal Humerus Fractures- A Comparative Study

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KEYWORDS

Distal humerus fractures; plate fixation; perpendicular plating; parallel plating

ABSTRACT

Distal humerus fractures are quite uncommon but pose significant challenges in management due to their complex anatomy and varied fracture patterns. Surgical intervention, particularly using plate fixation, is often necessary to achieve stable fracture union and restore functional elbow mobility. This prospective comparative study aimed to analyse the outcomes of distal humeral fracture management using perpendicular and parallel plating techniques. Thirty patients with distal humeral fractures underwent osteosynthesis with either perpendicular or parallel plating between November 2020 and October 2022 at Saveetha Medical College and Hospital in Chennai. The Mayo Elbow Performance Score has been utilized to measure the following assessment parameters: pain, radiological, stiffness and clinical union, and functional elbow ability at 6 weeks, 3 months, 6 months, and 1 year after the surgery.Both techniques yielded satisfactory outcomes in terms of fracture union and functional recovery. However, complications and biomechanical properties differed significantly between the two methods. Parallel plating demonstrated superior stability and resistance to plastic deformation, particularly in osteoporotic bone, suggesting potential advantages in managing comminuted distal humerus fractures with an intraarticular component. This study contributes valuable insights into the optimal management strategies for distal humeral fractures and highlights the importance of considering individual patient factors and fracture characteristics when selecting the most suitable surgical approach. Additional investigation is necessary to verify these results and improve methods of treatment for this difficult kind of fracture.

1. Introduction

Distal humerus fractures are uncommon, accounting for 2% to 5% of all fractures and having a bimodal age distribution. In males, the peak incidence occurs between the ages of 12 and 19, while in females, it typically occurs at 80 years and older [1,2]. While low energy injuries like minor falls cause fractures in the elderly, high-energy injuries like car accidents cause fractures in young adults [3,4]. The most common cause of injury is a simple fall from a standing height, which results in extra-articular fractures (40%). The second most prevalent type is complete intra-articular fractures, which account for 37%.The overall incidence of distal humerus fractures is rising, posing therapeutic issues, particularly in osteopenic bone where they are often multifragmented and have limited fixation choices due to complicated anatomy. To restore anatomical alignment as well as enable functional rehabilitation soon after the surgery, ORIF (open reduction and internal fixation) is frequently used to treat these kinds of fractures [5,6,7]. Most surgeons currently utilize two plates perpendicular to each other (90°-90°), one over the medial column and the other over the posterolateral or dorsolateral column. However, up to 35% of cases have issues, such as malunion and implant failure, especially in the patients who are older and whose bone quality is poor and low patient compliance. In these situations, the lateral column's lack of screw purchase is the main reason for failure. To attain a more stable initial fixation, especially in the osteoporotic bone, parallel plating-where the plates are positioned over the medial and lateral columns with their faces facing each other at 180°was introduced. According to theory, the implants would form the equivalent of a compression arch by interdigitating in the fragments of the distal fracture (next to the opposing plate). However, complications related to parallel plating include significant soft tissue damage and neurovascular compromise. The results of treatment are frequently linked to symptoms like weakness, pain, and stiffness in the elbow. This highlights the importance of having a stable, painless, and mobile elbow joint to perform their daily activities. Within the context of the fixation of an intraarticular fracture in the distal humerus, this study examines the biomechanical differences and similarities between the perpendicular as well as parallel locking plate systems.

2. Methodology

Prospective comparative research has been performed on 30 patients with distal humeral fractures who were randomized into 2 groups and underwent osteosynthesis using either perpendicular or parallel plating techniques between September 2020 and October 2022 at the Department of Orthopaedics, Saveetha Medical College and Hospital in Chennai. The study aimed to assess the outcomes of distal humeral fracture management with perpendicular versus parallel plating techniques, and the results were subsequently analysed following clearance from the institutional ethical committee.

Patients with skeletally mature individuals and distal humerus fractures met the inclusion criteria; patients with skeletally immature individuals, open fractures (grade 3), and those considered medically unfit for surgery were excluded. Every patient who took part gave their informed consent. Assessment was done at 6 weeks, 3 months, 6 months, and 1 year postoperatively to evaluate parameters such as pain, radiological, stiffness, and clinical union as well as functional outcomes (Elbow Range of motion, arc of elbow flexion and extension), assessed by utilizing the Mayo Elbow Performance Score.

Patients and their companions were asked to provide a thorough history at the time of admission in order to determine the cause of the injury and any related injuries. Detailed clinical examinations and radiological assessments were conducted to evaluate fracture patterns, deformities, and neurovascular status. The affected limb was then immobilized until the day of surgery in an above-elbow plaster slab. Anteroposterior and lateral radiographs were performed for fracture pattern determination, while 3D CT scans were employed to visualize articular fractures and identify complex fracture patterns. IBM SPSS Version 24.0 was used for the statistical analysis. NY / Armonk: IBM Corp. Standard deviations (SD) and means were used to express continuous data. Student's t-tests for paired samples and Student's tests for continuous variables were used to compare the data. It was determined that a P value which was less than 0.05 was measured to be statistically significant.

Surgical Technique:

All surgical processes have been carried out under general anaesthesia or regional anaesthesia, with patients positioned laterally and the involved limb supported over bolsters or arm support on the operating table. An extensile posterior skin incision was made, followed by the identification and gentle retraction of the ulnar nerve. It was possible to identify and release the triceps muscles on either side of the intermuscular septum. In some instances, a Chevron V-shaped olecranon osteotomy was performed in order to facilitate articular surface visualization in type C fractures. Additionally, we utilized the paratricipital or triceps splitting approach when dealing with other types of fractures. The articular segment needs to be rigidly attached to the distal humeral shaft or the medial and lateral columns (AO/OTA type A fractures and type C fractures following articular fixation). Plates that are parallel or orthogonal can be used to achieve this. We used both parallel and orthogonal plating techniques in our investigation.

Perpendicular plating:

It involves placing plates at roughly 90-degree angles on both columns. The lateral plate is typically positioned along the posterior aspect of the lateral column as far distal as feasible. Posterolateral plates are preferred because prominent lateral plates can cause hardware irritation in thin and active patients. The lateral column posterior curvature should be matched in the contouring of the lateral plate. The end of the plate is positioned just proximal to the capitulum's posterior articular surface to attain max. distal fixation. If the plate is positioned even farther distal, the radial head may impinge against the plate during extension, causing discomfort and motion’s limited range. A dynamic compression plate measuring 3.5 mm or its equivalent should ideally be used as the lateral plate. Typically, the medial plate is contoured to curve around the medial epicondyle and applied to the medial supracondylar ridge. Typically, the reconstruction plate is 3.5 mm in diameter to facilitate easier bending. Perhaps a more recent fracture-specific pre-contoured plate would be better. Following the repair of the fracture

segments, a 6.5mm cancellous screw or two K wires were used to secure the osteotomized olecranon using tension band wiring.

Parallel plating:

Two plates are positioned roughly parallel to one another on their individual supracondylar ridges in parallel plating. To connect the fragments of the articular to the humeral shaft, screws into the articular segment are positioned preferentially through the plates. In order to engage the fragments that are fastened to the opposing column and to gather as many articular fragments as possible, the longest screws must ideally be put through the plate. In order to enable columnar plate application, longitudinal K wires are utilized to temporarily secure the reconstructed articular segment to the shaft. 3.5 mm K wires are positioned distally and precontoured plates are subsequently temporarily applied to the lateral along with medial columns. Into the articular segment, as many screws as feasible are inserted through the plates. The screws must ideally engage as several articular fragments as possible and be as long as feasible. The olecranon fossa should not be punctured by screws since this can cause impingement. Subsequently, the plates are secured to the humeral shaft by means of eccentrically inserted first diaphyseal screws, which facilitate supracondylar fracture compression. If you want to reduce the effect of the stress riser, plates should end at different levels.

Postoperative Protocol:

Postoperatively, well-padded above elbow plaster was applied and the affected limb was elevated for the initial three days, followed by active finger movements and wrist mobilization starting on postoperative day (POD) 1. Intravenous antibiotics and analgesics were given for 2 days postoperatively and then changed to oral antibiotics and analgesics. Elbow range of motion exercises were initiated between POD 2 and 7 as pain was tolerated, with a gradual return to routine activities permitted at 6 months. Passively assisted extension exercises were administered to patients who underwent Chevron osteotomy, an approach that involves the extensor mechanism.

3. Result and Discussion

A total of thirty patients who had fractures of the distal humerus were randomized into 2 groups and studied between September 2020 and October 2022. Group 1 was managed with perpendicular plating, whereas Group 2 was managed with parallel plating. The patients mean age was 45.8yrs, with a range that went from 22 to 78 yrs in the group that received perpendicular plating. Conversely, the mean age of the patients in the group that received parallel plating was 42.2 yrs, with a range that went from 26 to 57 years. In our study, males were most commonly affected (Figure 1), and in both groups, the right limb was more commonly injured (Figure 2).

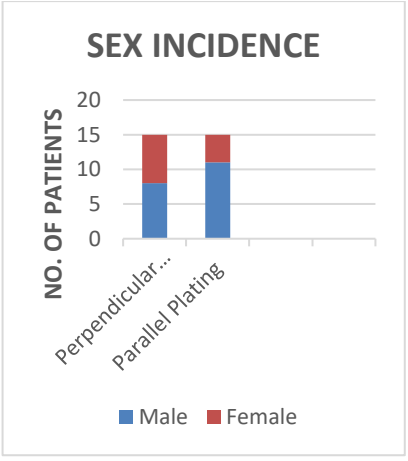

Figure 1: Gender Distribution

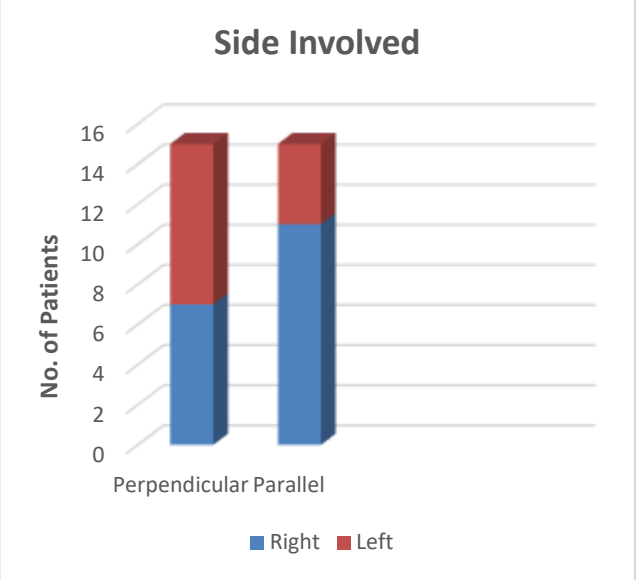

Figure 2: Side involved among the two groups

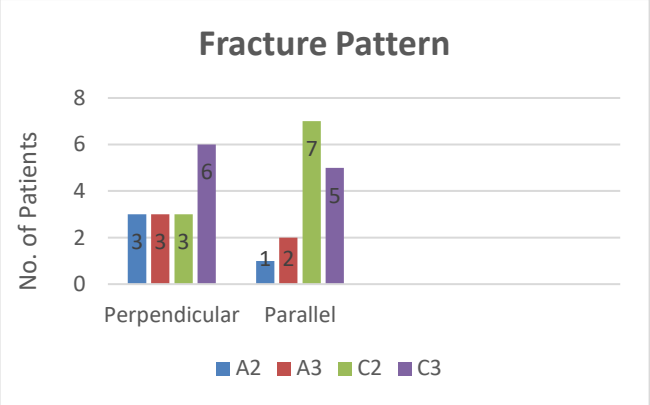

Figure 3: AO OTA Facture pattern types

The most frequent mechanisms of injury were simple falls and auto accidents. In both groups, only 30% of our cases were extraarticular transcondylar fractures, whereas 70% of our cases were completely articular fractures. The most prevalent complete articular types were arranged C3 > C2 in perpendicular plating groups and C2 > C3 in parallel groups (Figure 3). The average operating time was 141 minutes, which varies from 110 to 220 minutes. One patient had an associated distal radius fracture in the perpendicular plating group, and three patients had radial nerve palsy, one in the perpendicular group and two in the parallel plating group. Following an average 12-month follow-up, thirty patients with distal humeral fractures underwent surgical treatment using parallel and perpendicular plating. In our study, all patients primarily achieved radiologic fracture union. The average time to fracture union was about 12.5 weeks, which varies from 10 to 15 weeks. The average Mayo elbow performance score at the end of one year was 82.1 varying from 58 to 95. The findings were excellent among 3 patients, good for 7 patients, fair for 3 patients, and poor for 2 patients in perpendicular plating, whereas in parallel plating, the results were excellent among 5 patients, good for 8 patients, fair for 2 patients, and no poor outcome (Table 1). Paraesthesia along the ulnar nerve distribution, neuropraxia of the radial nerve, infection, stiffness, non-union at the site of osteotomy, and hardware prominence were the complications experienced by both groups. Three patients had superficial skin infections, which were treated conservatively with IV antibiotics and regular wound dressing. One patient received conservative treatment for numbness and paraesthesia along his little finger's ulnar border. Seven months after surgery, radial nerve neuropraxia in one patient showed signs

of spontaneous recovery. Elbow stiffness was noted in two patients, and one patient developed hardware prominence. Two patients underwent revision osteosynthesis using tension band wiring because they had a non-union at the site of the osteotomy. Table 2 shows that none of the lost to follow-up.

4. Discussion:

It is common for distal humerus fractures to be intra-articular and comminuted. Such fractures are challenging to treat because of this condition, the elbow's complicated anatomy, and the limited quantity of available subchondral bone. Dual plating for comminuted intraarticular distal humerus fractures is generally preferred for its stability over single plating. Parallel and perpendicular plating are the 2 most often used plating methods for the distal humeral fractures. Recent research suggests that fractures by the articular surface have been better stabilized by utilizing parallel plating approaches as the implants interdigitate with distal fragments, forming a compression arch.

Distal humerus fractures significantly impact elbow function. For social and economic well-being, maintaining a good functional elbow range of motion is crucial. Exposure, fixation, and post-operative rehabilitation are key factors influencing elbow function. Adequate exposure is essential for individual fracture fragment fixation, with olecranon osteotomy providing optimal visualization. The olecranon approach allows for full visualization of the capitulum, trochlea, radial head, and olecranon. Ring et al. [8] noted complications such as bursitis, implant prominence, and displacement of K-wires associated with olecranon osteotomy. In our study, hardware prominence was observed in one case, and 1 case of non-union at the site of osteotomy was reported.

Fracture patterns classified according to the Orthopaedic Trauma Association (OTA) play a significant role in patient outcomes. Patients with AO type A fractures tend to have better outcomes compared to those with AO type C fractures, underscoring the importance of OTA classification. A principle-based parallel-plate approach was introduced by Sanchez-Sotelo et al. [9] at the Mayo Clinic. In their demonstration, they depicted that the mean MEPS was 85 points, and the mean flexion-extension arc was precisely 99 degrees. The rate of excellent as well as good outcomes was 79.4%, which indicates that AO types C and A are more prevalent than type B fractures, a trend consistent with our findings. The increasing incidence of high-velocity injuries contributes to the higher prevalence of type C fractures compared to type A fractures.

In our study, fifteen cases underwent surgery using parallel plating, which provided rigid stability conducive to early rehabilitation. Parallel plating allows for the placement of lengthy screws along the lateral column, which can be challenging with traditional perpendicular plating, especially in the presence of an anterior capitellar breach. Importantly, our study revealed no non-unions or implant failures at the fracture site. This is consistent with the idea that parallel plating provides a stable construct by nature in specific clinical settings, which is backed by research by Sanchez-Sotelo et al. and Atalar et al. [9,10].

Athwal et al. [11] examined the results of 37 patients with type C distal humerus treated by LCP using a parallel plate technique. In their investigation, they observed that the average arc of motion for the elbow in flexion and extension was 97 degrees, and the average injury to the peripheral nerve was 82 points. Additionally, they reported that 5 out of 24 patients (16%) had postoperative nerve injuries. Similarly, one case developed radial nerve neuropraxia postoperatively in our research. This could be discussed by the fact that dissection for perpendicular plating is simpler and safer than for parallel plating methods.

Using distal humerus LCP, Lee et al. [12] compared the results of parallel and perpendicular plating techniques and discovered no discernible difference in the two approaches' outcomes. Similar results were found by Stoffel et al. [13] when they compared the effectiveness of parallel and perpendicular locking plate systems in the treatment of comminuted distal humerus fractures. Furthermore, there have been no variations among the groups in terms of operating time, time to union, or functional recovery.

The mechanical characteristics of perpendicular, as well as parallel plating systems for the distal humerus fractures, have been compared in numerous biomechanical investigations. Perpendicular and parallel plating were tested in a range of biomechanical parameters by Schwartz et al. [14], who found no appreciable variations in stability and fixation among the 2 systems. Additionally, because the load is distributed over a wide area and less stress is placed at the interface between the bone and plate, the parallel plating geometry provides better fixation stability in compression as well as rotation.

However, according to biomechanical analysis, Schemitsch et al. [15] found that plating that is applied parallel to one another offers more stability than plating that is orthogonal. In a varus-loading test, Zalavras et al. [16] found that the parallel plating approach outperformed the orthogonal plating approach biomechanically. In a humerus made of epoxy resin, Arnander et al. [17] conducted a straightforward transverse distal humerus osteotomy without involving the articular cartilage. They looked at bending forces in the sagittal plane and found that the parallel system was more rigid and strong.

According to the findings of Aslam and Willett et al. [18], "the functional result of AO orthogonal plating has been investigated in 26 patients over the age of 60 who were treated for Type C fractures. With a mean flexion arc of 112° along with a grip strength of 82percent in comparison to the uninjured side, 70% of patients had good to excellent outcomes. According to the findings of the meta-analysis conducted by Xianbin Yu and colleagues [19], there was not a statistically significant difference between the 2 groups in terms of the rates of excellent as well as good outcomes at the final follow-up, arc of elbow flexion and extension, range of motion of the elbow, or MEPS (P=0.87, P=0.18, P=0.58, P=0.39, and P=0.59, respectively)". On the basis of this information, it appears that the distal humerus fractures treatment with plating techniques that are either perpendicular or parallel can provide stable fixation, anatomical reconstruction, and satisfactory results.

In the current investigation, parallel plating showed noticeably higher resistance to plastic deformation and increased stiffness in compression and external rotation. Furthermore, perpendicular plating demonstrated a greater reliance on bone mineral density (BMD), especially in rotation, indicating that when repairing "comminuted distal humerus fractures with an intraarticular component in osteoporotic bone, perpendicular plating might not be as robust as the parallel system"

4. Conclusion and future scope

Our results indicate that both perpendicular and parallel plating techniques can achieve satisfactory outcomes in terms of fracture union and functional recovery. However, there are notable differences in complication rates and biomechanical properties between the two techniques. Parallel plating demonstrated greater stability and resistance to plastic deformation compared to perpendicular plating, particularly in osteoporotic bone. This implies that parallel plating might be helpful, particularly in patients with poor-quality bone, in cases of comminuted distal humerus fractures with an intraarticular component.

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Declarations:

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