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Distal humerus fracture fixation using anatomical distal humerus plate

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***Abstract*---Background**: The complex geometry of the distal humerus makes distal humerus fractures the rarest form of humerus fracture in the adult population. Their treatment is a challenge. The patients and orthopaedic surgeons are both significantly burdened by these injuries. The locking compression plate and distal humerus plate (LCP-DHP) system facilitates early mobilisation for distal humerus fractures by offering high-quality reconstructions and sufficient stability. **Objective**: The objective of this investigation is to assess the functional and radiological results of fixed distal humerus fractures using an anatomical humeral plate. We will evaluate functional outcomes using Mayo elbow performance (MEP) scores. **Materials and Methods**: A prospective study of 20 patients with supracondylar intercondylar humeral fractures was treated by anatomical distal humeral plates in the department of Orthopaedics at El-Menoufia university hospitals from November 2022 till October 2023. Age, sex, fracture type, mode of injury, limb involvement, associated injuries, follow-up, complications, and final outcomes were all taken into account when recording and analysing the variables of each patient. The patients were monitored at varying intervals, beginning with weekly visits for the first month, followed by one-month intervals for the subsequent six months, and finally, three-month intervals. **Results**: The results of our study, which examined 20 patents, indicated that 6 cases (30%) had outstanding results, 11 cases (55%) had good results, and 3 cases (15%) had poor results. Mean ± standard deviation of the score was 80.9 ± 8.48. **Conclusion**: The utilisation of fixed angle fasteners in locked compression plates has resulted in their increasing

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popularity, as they are perceived to provide superior fixation. Furthermore, they have the advantage of neocortical screw implantation, which reduces the likelihood of screw heads protruding into the joints. These distal humerus plates and secured compression plates are more likely to be beneficial for patients with osteoporotic bones, metaphyseal commination, and very low-type intra-articular fractures.

***Keywords*---**Supracondylar Intercondylar Fracture Humerus - Anatomical Distal Humerus Plates.

Introduction

As individuals age, the prevalence of humerus fractures increases, and they comprise approximately 8% of all adult fractures. Therefore, the process of clinical decision-making may be confounded by the condition of bone and comorbidities. The healthcare system and the patients are both substantially burdened by these injuries. Humeral fractures are managed on the basis of their location, which may impact the proximal, shaft, or distal aspect of the bone [(1)]

Classification of the Orthopaedic Trauma Association/AO The distal humerus fracture (DHF) is classified into three primary categories. Extro-articular (supracondylar fracture) type A, which is 80% extension. Single column intra-articular (partial articular): Type B. Type C: intra-articular fracture of both columns—no portion of the joint contiguous with the shaft (complete articular). [(2)] The distal humerus fracture is the most uncommon form of humerus fracture and presents a challenging treatment due to its complex geometry. The distribution of distal humerus fractures is bimodal, which is comparable to that of humeral shaft fractures. The maxima are observed in females aged 80 years and older and juvenile males aged 12–19. The primary cause of low energy distal humerus fractures in the geriatric female population is a ground level fall, whereas motor vehicle accidents are a frequent occurrence in the younger male population where these injuries occur. [(1)]

Effective management of the distal humerus fracture is a challenging endeavour, as it is one of the most complex injuries. In the past, treatment recommendations varied from strictly conservative to open reduction and internal fixation. [(3)]

It is imperative to restore joint congruency for patients with distal humeral fractures, regardless of their age, in order to achieve the best possible results. Since this is the case, conservative treatment frequently results in an agonising limited range of motion (ROM). Thus, for the past few decades, the preferred treatment has been open reduction and internal fixation (ORIF). [(4)]

The therapeutic options for both humeral shaft and intercondylar fractures have an impact on the treatment of these injuries. The insufficient fixation of the brief distal fragment is the limitation of intramedullary nailing and plating with 4.5

mm compression or locking techniques.. There is also a concern regarding plate impingement at the olecranon fossa, which subsequently limits elbow extension. Lambda plate, dual plating, and metaphyseal plate fixation are alternative plating techniques that have been proposed as potential solutions to this problem; however, they have not been proven to be effective or reliable.

In order to resolve these complex fractures, the extra-articular distal humerus plate has been specifically designed. It has been anatomically pre-contoured to be positioned proximally along the central humeral diaphysis and distally on the lateral supracondylar ridge. (5)

Nevertheless, unsatisfactory outcomes do occur in 20%–25% of cases, despite surgical treatment. Nerve dysfunction, extensor mechanism dysfunction, posttraumatic degenerative changes, wound and skin infections, avascular necrosis, and implant failure are all potential complications that may arise following operative fixation. Fixation techniques that are inadequate frequently lead to implant failure, which is a substantial impediment to the successful repair of fractures. The necessity of overcoming and averting these complications, particularly in the presence of poor bone quality, has led to an active search to identify the gold standard for fixation of distal humerus fractures. (6)

Providing high-quality reconstructions and adequate stability, the locking compression plate and distal humerus plate (LCP-DHP) system facilitates early mobilisation for distal humerus fractures. It has been demonstrated that this method attains a high rate of union and adequate elbow joint function. (7)

There are numerous benefits to anatomical DHP. In order to accommodate the unique fracture pattern, implant implantation is facilitated by the use of medial and posterolateral plates. Plates are precontoured to ensure anatomical fit. The posterolateral plate with lateral support provides the option of two additional fasteners being positioned lateral to medial. The diverging nature of the fasteners in the locked apertures guarantees adequate construct stability, rendering monocortical fixation sufficient. Three distal fasteners are used to secure the capitulum with posterolateral plates. The fixation of extremely distal fractures is facilitated by five fastening alternatives into the distal block, particularly in osteoporotic bone, as the screws are also secured to the plate. The fixation is fortified by the girder-like structure that is generated by the two-plate construct.
During elbow flexion, the posterolateral plate serves as a tension band, while the medial plate provides support for the medial side of the distal humerus. The rigidity and strength of orthogonal plates are significantly higher than those of other constructs for the various movements (flexion, extension, and rotation). Also, LCPs may be employed as a neutralisation plate, with a shortened plate and one fewer fastener per fragment. (8)

Patients and Methods

During the period of December 2022 to November 2023, a prospective investigation was conducted at El-Menoufia University Hospitals on patients who

had distal humeral fractures (extra and intra-articular) that were treated with anatomical distal humeral plates using ORIF.
Mature skeleton, recent supracondylar intercondylar fracture of the humerus, and. these were the inclusion criteria. Skeletally immature patients, neglected fractures of the humerus, concomitant neurovascular injury, previous elbow surgery, loss of follow-up, pre-existing deformity, disability, infection, and patients with comorbidities such as rheumatoid arthritis are among the exclusionary criteria.

Included cases had an average age of 41.8 ± 17.92 years (range: 18–68). According to the sex distribution in all cases examined, there were 9 males (45%) and 11 females (55%). In each of the cases that were examined, 12 (55%) were affected on the right side and 8 (45%) on the left side.

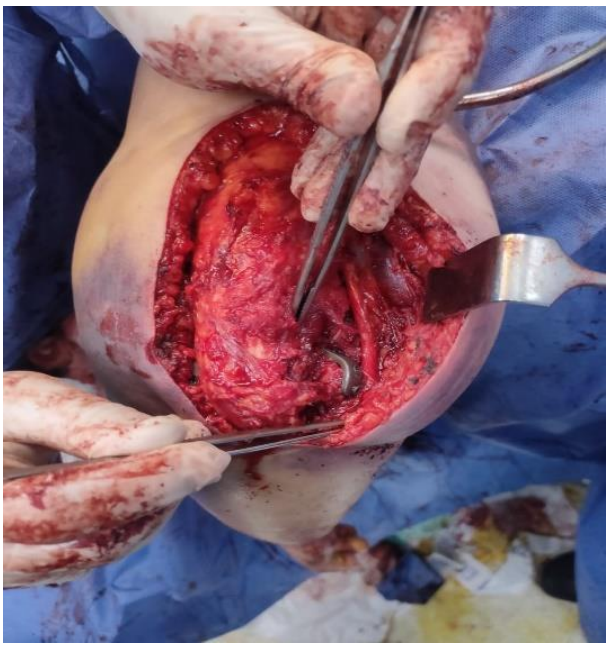
The fracture classification in the patients under study was as follows: A1: 20%, A2: 30%, A3: 10%, and C1: 40% (Table-1). Road traffic accidents account for 70% of the cases examined, while falls on the elbow and direct trauma account for approximately 30% of fractures. (Table-2).

Operative and Surgical Technique

In all cases, the forearm was suspended on the side over an arm support in the lateral decubitus position, with the elbow flexed at 90°. Routinely, tourniquets were implemented for each patient. Skin was disinfected, and the operating field was draped from the midarm to the hand. We employed a posterior midline longitudinal incision (Figure.1A). Triceps division or olecranon osteotomy were implemented in accordance with the extension of the articular surface (Figure.1B). The ulnar nerve was isolated and safeguarded (Figur.2). The K-wire or a fastener was employed to secure the medial and lateral condyles. The medial and lateral columns were reduced and provisionally secured to the metaphysis using crossed 2 mm K-wires when the articular surface reconstruction was completed. After that, anatomical distal humeral plates were employed to reconstruct both columns. Plates were affixed at a 90° angle to one another (orthogonal plating). The plate was occasionally required to be slightly bent to accommodate the unique morphology of the distal humerus in certain examples. After the procedure concluded, the delicate tissues were reconstructed. The limb was immobilised in a slab located above the elbow, with the elbow in a 90-degree flexion, and the patient in a mid-prone position. The incision was closed in layers over a negative vacuum drain. In addition to elevating the operated limb, the patient was advised to continue manipulating the shoulder joint and extremities. Furthermore, exercises were implemented to improve the strength of the hand clasp. The limbs were clinically assessed in terms of pain alleviation, range of motion, functional enhancement, and instability. The radiological evaluation was conducted using antero-posterior and lateral views. Drainage was eliminated after 48 hours. The sutures were extracted from the epidermis after two weeks of postoperative recovery. A controlled assisted active mobilisation of the elbow was initiated after one week, and active mobilisation was performed after two weeks. Beginning in the first week and continuing for a month, the patients were evaluated clinically and radiologically at different intervals following the operation. Subsequently, for an additional three months, at intervals of four weekends to six

months. During each visit, the grade of the union and fracture callus was evaluated radiologically, and the functional limb was evaluated using the Mayo Elbow Performance Scoring (MEPS). (Figure.3).[9]

(Fig.1)A: posterior midline incision, B: Triceps splitting approach



(Fig.2) Ulnar nerve exploration

Function	Definition	Points	Score classification
Pain	None	45	Excellent > 90
	Mild	30	
	Moderate	15	
	Severe	0	
Motion	Arc > 100	20	Good, 75–89
	Arc 50–100	15	
	Arc < 50	5	
Stability	Stable	10	Fair, 60–74
	Moderate instability	5	
	Gross instability	0	
Function	Comb hair	5	Poor < 60
	Feed	5	
	Hygiene	5	
	Shirt	5	
	Shoe	5	
Total		100	

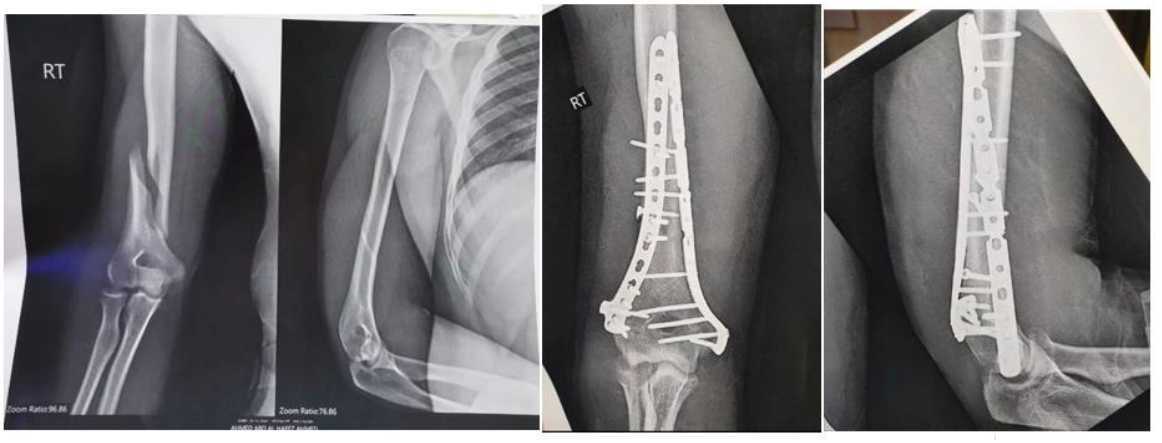
(Fig.3) Mayo Elbow Performance Score [9]

Pre-operative X-ray

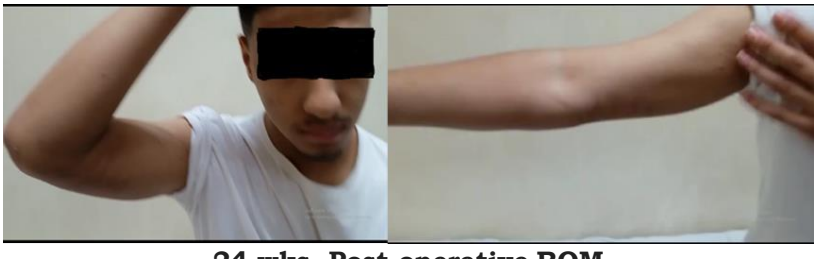
24 wks post-operative X-ray

24 wks. Post-operative ROM

(Fig.3) case 1, preoperative x-ray, postoperative x ray after 6 month & clinical photo after 6 month.



Pre-operative X-ray **24 wks. Post-operative X-ray**



24 wks. Post-operative ROM

(Fig.4) case 2, preoperative x-ray, postoperative x ray after 6 month & clinical photo after 6 month.

Pre-operative X-ray **24wks post-operative Xray**

24 wks post-operative ROM

(Fig.5) case 3, preoperative x-ray, postoperative x ray after 6 month & clinical photo after 6 month.

Results

The collected data was coded, processed, and analysed using the SPSS (Statistical Package for Social Sciences) version 22 for Windows® (IBM SPSS Inc, Chicago, IL, USA).

We examined 20 patients, with a mean age of 41.8 ± 17.92 years (range: 18–68). The average duration of prospective follow-up for these 20 patients was 4-9 months. Anatomical distal humeral plates were used to internally repair all fractures after they were openly reduced. The average operative time was 80 minutes, with a range of 70 to 100 minutes. The fractures were all united within 12-18 weeks, with an average of 13.80 weeks. Nineteen patients (95.0%) were alleviated without experiencing any postoperative complications. Postoperative

complications were experienced by one patient (5.0%). 1 case (5%) experienced delayed union. It was noted that no patient had reported any of the following: profound infection, myositis ossificans, screw in olecranon fossa, implant failure, or non-union (Table-3).

Functional evaluation:

The score was reduced by 20 points in 14 cases (70%) where the arc of motion exceeded 100 degrees of flexion. The score was reduced by 15 points for the six remaining cases (30%), which had an arch of motion less than 100 degrees of flexion but more than 50 degrees. No cases have been documented in which the arc of flexion is less than 50 degrees.

The score was reduced by 45 points in 8 cases (40%) due to the absence of discomfort, as determined by the pain scale. The score was reduced by 30 points due to the fact that 8 cases (40%) were characterised by moderate discomfort. Moderate discomfort was present in four cases (20%), which resulted in a deduction of 15 points from the score. There are no documented instances of severe agony.

Based on the function, 12 cases (60%) deducted 25 points from the score, 4 cases (20%) deducted 20 points from the score, 4 cases (20%) deducted 15 points from the score, and no cases deducted less than 15 points from the function. The MEPS scores of the patients under investigation were as follows: 6 cases (40%) achieved a score of 100 points, 6 cases (30%) achieved a score of 85 points, 3 cases (15%) achieved a score of 80 points, 2 cases (10%) achieved a score of 75 points, and 3 cases (15%) achieved a score of 65 points (Table.4).

The score had a mean of 80.9 ± 8.48 standards deviations. 6 cases (30%) had outstanding results, 11 cases (55%) had good results, and 4 cases (15%) had acceptable results, according to the MEPS results analysis of the patients under study. In no case was a negative outcome recorded. (Table.5).

Table (1): Showing Types of Fracture (AO Classification)

Fracture AO/type	**Study cases N = 20**	
	Number	**Percent**
A1	4	20 %
A2	6	30 %
A3	2	10 %
C1	8	40%

Table (2): Etiology of fractures in the cases of the study.

Etiology of fractures	Study cases	
	N = 20	
	Number	Percent
Road traffic accidents	14	70 %
Fall & Direct trauma	6	30

Table (3): Outcome & complications.

Variables	Study cases N = 20	
	Number	Percent
Union		
United	19	95
Delayed union	1	5
Infection		
No	20	100
Yes	0	0

Table (4): RESULTS OF THE MAYO ELBOW PERFORMANCE SCORE

Function	Points	Definition (points)	No. of elbows	Mean score
Pain	45	None (45)	8	33%
		Mild (30)	8	
		Moderate (15)	4	
		Severe (0)	0	
Motion	20	Arc< 100^0(20)	12	18%
		Arc 50-100(15)	8	
		Arc > 50^0)5)	0	
Stability	10	Stable (10)	20	10%
		Moderate (5)		
		Severe (0)		
Functions	25	25 points	9	20.75%
		20 points	7	
		15 points	2	
		10 points	2	
		5 points	0	

Total	100		20	81.7

Table (5): Mayo Elbow Performance Score.

Variables		**Study cases N = 20**	
Mayo Elbow Performance Score	Mean ± SD	80.9 ± 8.48	
	Median (Range)	81 (65 - 95)	
		Number	**Percent**
Mayo Elbow Performance Score categories			
Fair		3	15 %
Good		11	55 %
Excellent		6	30 %

Discussion

To facilitate rapid and appropriate rehabilitation, the anatomic reconstruction of the articular surface, the restoration of the distal humerus's overall geometry, and the stable fixation of the fracture fragments are necessary for the restoration of painless and satisfactory elbow function following a distal humerus fracture, particularly an intra-articular fracture.

They may be technically difficult to achieve, despite the fact that these objectives are now widely recognised by the orthopaedic community [10]

Govind et al. (2017) [11] A total of 30 adult patients, aged 23 to 66, underwent surgery for distal humerus fractures. The majority of cases (53.33%) yielded excellent results, while the remaining (36.33%) yielded good, while 6.66% yielded middling and 3.33% yielded poor results. From 18 to 68 years of age, we operated on 20 patients with distal humerus fractures in contrast to our investigation. In the total number of cases, the majority (55%) achieved satisfactory results, while the remaining (30%) achieved exceptional results and the remaining (15%) achieved fair results with no poor results.

Patient admission and surgery were separated by an average of 7.8 days (range: 4-13 days) in this investigation. This is marginally longer than the average time spent between patient admission and surgery in our study, which was 2.35 days (range: 2-7 days). The average duration to union in this survey was 13.8 weeks, with a range of 12 to 18 weeks, which was comparable to the union rate in our study.

This study's findings demonstrated that three patients (10%) developed superficial wound infections, two patients (6.66%) developed transient ulnar nerve palsy, one patient (3.33%) experienced screw loosening (intercondylar cancellous screw), two patients (6.66%) experienced metal prominence (olecranon K-wire and lateral column plate), and three patients (10%) experienced occasional mild postoperative pain. In stark contrast to our investigation, we encountered only one patient (5%) who experienced delayed union.

The anatomically pre-shaped distal humerus locking compression plate system was found to be beneficial in facilitating early postoperative rehabilitation by providing stable fixation of intercondylar humerus fractures in both studies and was contingent upon the results of this study and our study.

Patel J et al. (2017) [10] the average age of the 31 consecutive patients who underwent surgery for distal intercondylar humerus fractures was 41.2 years. 26 C and 5 B categories were assigned to the patients in accordance with the AO classification. A posterior trans-olecranon approach was employed with the 3.5 mm precontoured distal humerus medial and lateral anatomical locking plate (90:90 orthogonal) system. In the mean follow-up period of 10 months (range 6–20 months), the mean MEPS was 87.9 points out of 100 (range 55–100), and the mean elbow flexion was 115.8o (range 85o–150o). Based on a range of 5 degrees to 35 degrees, the average deficit in extension was 19 degrees. The Mayo Elbow Performance Score indicated that 19 patients (61%) achieved a mean exceptional result (90–100), 9 patients (29%) achieved a good result (75–89), 1 patient achieved a middling result (60–74), and 2 patients achieved a poor result.
sub-60.

Our analysis was conducted in comparison to a series of 20 patients who underwent surgery for distal humeral fractures. The mean age of these patients was 41.8. These patients were categorised as 12 A and 8 C in accordance with the AO classification. We employed anatomical distal humeral plates and conducted follow-up for an average of 4-9 months. The mean MEPS was 81.65 ± 8.90.

The arc of motion indicated that 14 cases (70%) had an arch of motion greater than 100 degrees of flexion, while the remaining 6 cases (30%) had an arch of motion less than 100 degrees of flexion but greater than 50 degrees. The net results were as follows: 55% of the cases achieved good results, 30% achieved excellent results, and 15% achieved fair results. No cases had poor results.

A total of 29 patients (93.5%) achieved complete union, with an average time of 16 weeks (range 12–24). Furthermore, there were four superficial infections, three clinically prominent hardware, and one ulnar neuroapraxia that did not result in any distress. Two fractures did not union. No revision surgery was necessary for any of the complications mentioned above. Bicolumnar fractures are associated with an average non-union rate of 6%. In the context of our study, union was accomplished in 19 patients (95%) with an average time required of 13.8 weeks (range: 12-18 weeks). Delayed union was the only complication presented by one patient.

The studies both agreed that the following treatment procedure is effective for complex supra-intercondylar fractures of the distal humerus: open reduction and internal fixation with a precontoured distal humerus anatomical locking plate system. With a favourable functional outcome and low rates of complications, this method leads to the restoration of the articular surface anatomy, stable fixation, and early mobilisation.

Patel I et al. (2023).[12] 20 patients with intra-articular AO/OTA C-type distal humerus fractures that were displaced and treated with ORIF had a mean MEPS of 93.5. Within this series, 17 patients (85%) obtained exceptional outcomes, while 3 patients (15%) achieved satisfactory outcomes. In contrast to our study, the mean MEPS of displaced A&C type distal humerus fractures in 20 patients was 81.65 ± 8.90 following ORIF. The outcomes of three cases (15%) were deemed adequate, 11 cases (55%) were deemed excellent, and six cases (30%) were deemed outstanding.

Only two patients (10%) developed superficial infections; however, both patients recovered after receiving appropriate antibiotic treatment. None of the patients in our study experienced implant failure, myositis ossificans, postoperative ulnar nerve palsy, or nonunion. This is consistent with our own investigation, in which only one patient (5%) exhibited delayed union.

In the majority of cases (11 cases – 55%), mobilisation was initiated after three weeks, seven cases after four weeks (35%), and one case after two weeks (5%). In a single instance, mobilisation was initiated after six weeks due to the patient's humerus shaft fracture. In comparison to our study, mobilisation was initiated within one week postoperatively and continued for up to three weeks, with fracture fixation attained between two and four weeks, depending on the patients' comfort.

A postoperative study determined that a vigorous physiotherapy regimen is essential for optimal outcomes. In order to achieve rigid internal fixation, the most effective method is low-profile anatomical plate fixation, which offers optimal biomechanical stability. Consequently, early mobilisation can be initiated, and a favourable functional outcome can be attained with a low complication rate. The findings of our investigation on early mobilisation are strongly corroborated by these findings.

Our investigation included 20 patients, with 55% of them being adult and 45% being elderly. The average duration of follow-up for these 20 patients was 4-9 months. Anatomical distal humeral plates were used to internally repair all fractures after they were openly reduced. Of the total, 55% were female and 45% were male. Eight cases (40%) were affected on the left side, while twelve cases (60%) were affected on the right side. Six cases (30%) involved forearm injuries, while fourteen (70%) were the result of road traffic accidents. AO classification was used to categorise the injuries. There were 4 cases of type A1 fracture (20%), 6 cases of type A2 fracture (30%), 2 cases of type A3 fracture (10%), and 8 cases of type C1 fracture (40%). There were 19 patients (95.0%) who were alleviated without experiencing any postoperative complications. Postoperative complications were experienced by one patient (5.0%), who experienced slow union. Deep infection, myositis ossificans, and screw in the olecranon fossa had not been reported by any patient. Failure of the implant, non-union. The findings of our investigation indicated that 3 cases (15%) had a fair outcome, 11 cases (55%) had a decent outcome, and 6 cases (30%) had an excellent outcome. The score had a mean of 80.9 ± 8.48 standards deviations.

The primary constraints of our investigation are the limited sample size and the brief follow-up period. The duration of this follow-up is insufficient to address the long-term progression of osteoarthritis. We are unable to conduct a direct comparison with other plating systems or techniques due to the fact that we have only employed one form of plating and technique.

Conclusion

The internal fixation of intercondylar fractures of the distal humerus is successfully managed through the use of the double plating technique. The provision of anatomical distal humeral plates was advantageous in facilitating the early postoperative rehabilitation of supracondylar intercondylar humerus fractures by ensuring secure fixation. The final results are significantly influenced by rigid fixation and early elbow mobilisation. The final results are adversely affected by Fracture Type C1. The olecranon-osteotomy approach offers superior visualisation and greater control over the elbow joint, particularly in the C1 type.

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