



## Internal fixation of humeral shaft fractures using a dynamic compression plate: A prospective study

### Arindam Bhol\*

Junior Resident

Dr KNS Memorial Institute of Medical Sciences  
225001, W45R+7X7 Faizabad Rd., Barabanki, India  
<https://orcid.org/0009-0008-3082-9684>

### Supriya Thakur

Junior Resident

Dr KNS Memorial Institute of Medical Sciences  
225001, W45R+7X7 Faizabad Rd., Barabanki, India  
<https://orcid.org/0009-0000-1279-1928>

### Pratik Dewangan

Junior Resident

Dr KNS Memorial Institute of Medical Sciences  
225001, W45R+7X7 Faizabad Rd., Barabanki, India  
<https://orcid.org/0009-0004-5432-1309>

### Vishal Kumar

Senior Resident

Dr KNS Memorial Institute of Medical Sciences  
225001, W45R+7X7 Faizabad Rd., Barabanki, India  
<https://orcid.org/0009-0008-6467-0923>

### Parijat Gupta

Professor, Head of the Department of Orthopaedics

Dr KNS Memorial Institute of Medical Sciences  
225001, W45R+7X7 Faizabad Rd., Barabanki, India  
<https://orcid.org/0009-0001-2712-4076>

**Abstract.** Fractures of the humeral shaft present a challenge due to their unique anatomical and biomechanical characteristics. Fixation with a dynamic compression plate is a widely adopted technique for the surgical management of these fractures, aiming to achieve stable fixation and promote early mobilisation. This study aimed to evaluate the clinical and functional outcomes of dynamic compression plate fixation in humeral shaft fractures. This prospective study included 40 patients with displaced humeral shaft fractures, including Grade I and II open fractures. Preoperative assessments comprised clinical examinations and radiographic evaluations. Surgical fixation was performed using a dynamic compression plate, and postoperative follow-up was conducted at 2 weeks, 6 weeks, 3 months, and 6 months. Functional outcomes were assessed using the Modified Stewart & Hundley classification, and statistical analysis was

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\*Corresponding author



carried out. The study cohort had a mean age of 32.64 years ( $\pm 4.77$ ) and was predominantly male (65%). The most common cause of injury was road traffic accidents (55%). Type A fractures were the most frequent (42.5%), with 70% involving the right upper limb. The mean time to union was  $4.58 \pm 1.06$  months. At 6 months, 10 patients had excellent outcomes, 21 had good, 8 had fair, and 1 had a poor outcome ( $p < 0.0001$ ). Preoperative complications included multiple injuries. Postoperative complications were minimal, with only one case of malunion reported. The findings suggest that dynamic compression plate fixation is an effective method for the management of humeral shaft fractures, demonstrating significant improvements in alignment and functional outcomes, with low complication rates and favourable union times. These results support the reliability of dynamic compression plating in optimising treatment approaches and improving patient outcomes

**Keywords:** surgical fixation; fracture healing; orthopaedic surgery; clinical outcomes; range of motion

## Introduction

The current study is of significant importance as it relates to the optimal management of humeral shaft fractures, which, despite their relative prevalence, present unique challenges in the selection of appropriate treatment. There is a critical need to balance the advantages of surgical interventions, such as plate osteosynthesis and intramedullary nailing, which enable early mobilisation and anatomical restoration, against the benefits of non-operative approaches, which take advantage of the humerus's high healing potential, in light of evolving trends in orthopaedic care. Furthermore, this study is particularly relevant as it examines the efficacy of dynamic compression plating (DCP) fixation in the management of these fractures, providing insights into its reliability, safety, and potential to optimise patient outcomes. This research has the potential to improve patient recovery, reduce complications, and support individualised treatment strategies in orthopaedic practice while also contributing to clinical knowledge.

J.J. Olson *et al.* [1] noted that humeral shaft fractures account for 3-5% of all adult fractures, with the majority occurring in the middle third of the bone. S. Goyal *et al.* [2] observed that although many humeral fractures heal successfully with non-operative methods, the trend has shifted towards internal fixation to facilitate early mobilisation and restore function more rapidly. M. Hardy & L.M. Feehan [3] emphasised the effectiveness of conservative treatments, such as functional bracing, skeletal traction, and shoulder spica casts, particularly in cases where the humerus's inherent healing capacity is sufficient. Similarly, A.U. Burki *et al.* [4] highlighted the success of functional bracing in achieving favourable outcomes in humeral diaphysis fractures, further underscoring the humerus's potential for non-surgical recovery.

U. Kandemir *et al.* [5] reported that plate osteosynthesis is widely regarded as the gold standard for treating humeral shaft fractures due to its capacity to provide rigid fixation. However, they cautioned that careful protection of the radial nerve is essential during the procedure. R.K. Bhartiya *et al.* [6] suggested that intramedullary nailing (IMN) is a viable alternative, particularly for osteoporotic bone, as it preserves the fracture haematoma, allows for load-sharing, and involves minimally invasive techniques. D. Angachekar *et al.* [7] concluded that both DCP and IMN produced comparable functional outcomes in humeral shaft

fractures. The choice between these methods should depend on the surgeon's expertise and the specific needs of the patient. Similarly, R.K. Chandan *et al.* [8] found that although both DCP and interlocking nailing (ILN) achieved similar union rates and functional results, DCP had the advantage of fewer complications, yielding better outcomes in terms of pain management and shoulder function. In agreement, B. Hussain *et al.* [9] concluded that DCP not only facilitated faster bone union but also offered superior functional outcomes and fewer complications compared to ILN in patients with humeral shaft fractures.

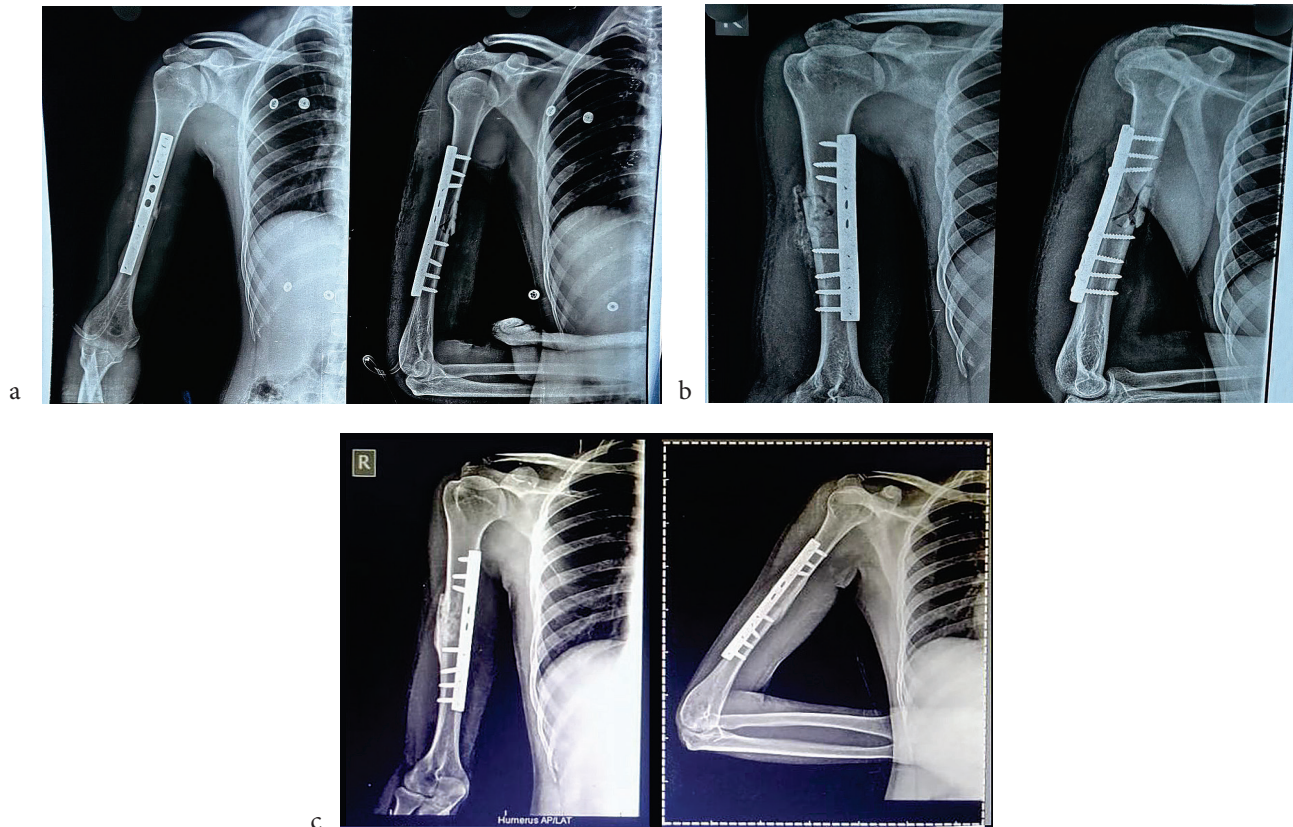
This study aimed to evaluate the clinical and functional outcomes of DCP fixation in the management of humeral shaft fractures, considering recent advancements in implant design and surgical techniques. By bridging the gap between traditional approaches and modern innovations, the findings aim to inform clinical decision-making and raise the standard of care in orthopaedic practice.

## Materials and Methods

This prospective study was conducted in the Department of Orthopaedics, Dr. KNS Memorial Institute of Medical Sciences, Barabanki. The sample was comprised of 40 patients using humeral shaft fractures treated with a dynamic compression plate. The study adhered to the ethical principles outlined in the Declaration of Helsinki [10]. Prior to commencement, approval was obtained from the local Institutional Review Board (Letter No. MIMS/2022/EX/211), and informed consent was obtained from all participants. Patients were included according to the following criteria: displaced fractures of the humeral shaft, age above 18 years, Grade I or II open fractures, multiple injuries, nerve injury, angulation greater than 15 degrees, and non-compliance with conservative treatment. Exclusion criteria included Grade III open fractures, nonunion, delayed union, and pathological fractures. A preoperative evaluation was carried out, including medical history, clinical examination, and standard radiographs of the humerus (AP and lateral views) encompassing the shoulder and elbow joints. Initial management involved the application of a U-slab until surgery. If required, electroneuromyography was performed to exclude nerve compression, traction injury, or complete nerve damage. Routine investigations were undertaken, and informed consent along with physician clearance fo

fitness was obtained. These investigations included: X-ray of the humerus (AP and lateral views) with shoulder and elbow joints; blood tests (CBC, ESR, PT INR); urine analysis (albumin, sugar, microscopy); blood grouping and Rh typing; HIV, HBsAg, and HCV tests; liver and kidney function tests (LFT & KFT); chest X-ray and ECG; blood sugar

levels; RT-PCR test for COVID-19. Postoperatively, patients were followed up at intervals of 2 weeks, 6 weeks, 3 months, and 6 months. X-rays were taken at 6 weeks, 3 months, and 6 months to assess fracture healing (Fig. 1). Functional outcomes (classified as excellent, good, fair, or poor) were evaluated using a modified Stewart & Hundley classification.



**Figure 1.** X-rays of patients

**Notes:** a – 1-month post-op; b – 3-month post-op; c – 6-month post-op

**Source:** compiled by the authors

A limitation of the study was the absence of an assessment of rotational movements (external and internal rotation) in the shoulder joint. Although the study focused on abduction/adduction and flexion/extension, the inclusion of rotational movements would have enabled a more comprehensive evaluation of functional recovery. Statistical analysis was conducted using SPSS software (version 26.0; SPSS Inc., Chicago, Illinois, USA) for Windows. All continuous variables (e.g. mean age, duration of surgery, blood loss, range of movements, and time to union) were expressed as mean (standard deviation) or range, depending on the data distribution. Analysis known as the analysis of variance (ANOVA) was used to compare the means of two or more groups. A p-value <0.05 or <0.001 was considered statistically significant.

## Results and Discussion

The DCP is preferred over the locking compression plate (LCP) for humeral shaft fractures due to its ability to

provide axial compression, promoting primary bone healing and superior load-sharing. Unlike the LCP, which offers rigid fixation independent of bone quality, the DCP is more effective in non-osteoporotic, simple, and wedge-type fractures, ensuring early mobilisation and faster recovery. This study highlighted the efficacy of DCP fixation.

Among the 40 patients, the predominant age group was 26-30 years (37.50%), with an average age of  $32.64 \pm 4.77$  years. The majority were male (65%), while females accounted for 35%. Regarding occupation, most participants were labourers (45%). The most common cause of injury was road traffic accidents (RTA), accounting for 55%. Regarding pre-operative complications, Grade I open fractures were observed in 3 cases (7.5%), while Grade II open fractures were significantly more common, affecting 37 patients (92.5%). Fracture classifications revealed that 42.50% had Type A fractures. Injuries predominantly affected the right limb (70%), with the left limb being involved in 30% of cases (Table 1).

**Table 1.** Clinico-demographic characteristics of the enrolled patients (n = 40)

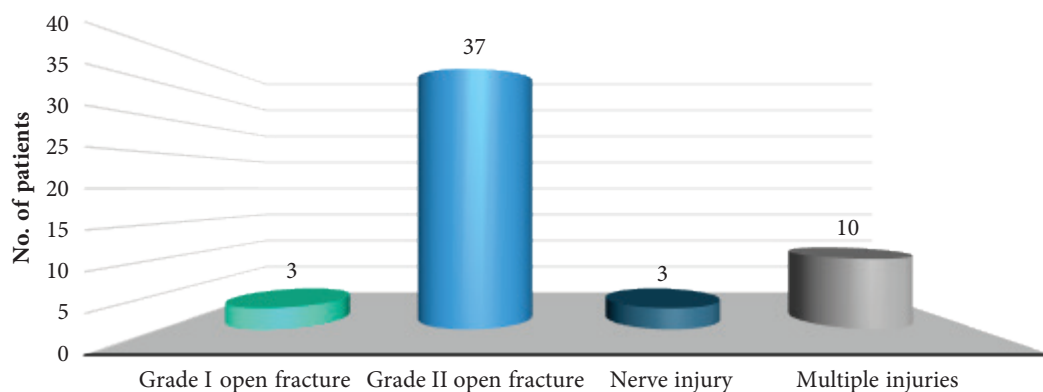
Clinico-demographics	Frequency	%
Age (years)		
18-25	6	15.00
26-30	15	37.50
31-35	11	27.50
36-40	8	20.00
Mean $\pm$ SD	32.64 $\pm$ 4.77	
Gender		
Male	26	65.00
Female	14	35.00
Occupation		
Professional/White collar	3	7.50
Skilled trades/Blue collar	12	30.00
Labourers	18	45.00
Student	7	17.50
Nature of injury		
RTA	22	55.00
Fall from height	13	32.50
Animal hit	5	12.50
Fracture classification (AO)		
Type A	17	42.50
Type B	11	27.50
Type C	12	30.00
Limb involved		
Right (dominant)	28	70.00
Left (non-dominant)	12	30.00

**Source:** compiled by the authors

Regarding the pre-operative complications, Grade I open fractures were observed in 3 (7.50%) of the cases, whereas Grade II open fractures were observed in 37 (92.5%) patients. Nerve injury was identified in 7.5% of the patients. Additionally, a significant proportion of the patients (25%) sustained multiple injuries (Fig. 2). Apart from Type A fractures, in Type B (wedge) fractures, the DCP plate is applied in neutralisation mode, whereby interfragmentary screws first secure the wedge fragment, and the plate then acts to protect against torsional and bending forces. In Type C (multifragmentary) fractures, the DCP plate is used in bridge plating mode, spanning the

fracture site while maintaining alignment of the proximal and distal fragments, thereby allowing indirect healing through callus formation.

In the initial treatment phase, 60.00% of patients were managed with a U-slab, 7.50% underwent surgical debridement, and 32.50% received alternative treatment. The average duration of surgery was  $148.00 \pm 13.47$  minutes, with an average blood loss of  $217.00 \pm 43.22$  mL, indicating the considerable surgical intervention required for these patients (Table 2). The range of movement in patients improved significantly over the follow-up periods of 6 weeks, 3 months, and 6 months (Table 3).

**Figure 2.** Pre-operative complications of the enrolled patients

**Source:** compiled by the authors

**Table 2.** Initial treatment of the enrolled patients

Initial treatment	Frequency	%
U-slab	24	60.00
Debridement	3	7.50
Other treatments	13	32.50
Duration of surgery (min)	148.00 ± 13.47	
Blood loss (mL)	217.00 ± 43.22	

Source: compiled by the authors

**Table 3.** Range of movement at follow-up evaluations

Range of movement	At 6 weeks	At 3 months	At 6 months	p-value
Shoulder abduction/adduction	150.12 ± 10.34 (141-160)	156.23 ± 8.78 (144-166)	162.45 ± 5.67 (152-172)	F = 21.10 p < 0.0001*
Shoulder flexion/extension	141.56 ± 12.45 (130-152)	146.78 ± 10.29 (134-157)	150.90 ± 8.87 (141-162)	F = 7.743 p = 0.0007*
Elbow flexion/extension	130.89 ± 10.98 (120-144)	135.34 ± 8.45 (125-146)	140.23 ± 6.34 (131-152)	F = 11.28 p < 0.0001*

Source: compiled by the authors

The outcomes based on the Modified Stewart & Hundley classification demonstrated significant improvement over time. At 6 weeks, none of the patients achieved an excellent outcome; at 3 months, 5 patients had attained this level, increasing to 10 patients at 6 months. The overall improvement was statistically significant, with a p-value of less than 0.0001 (Table 4). The mean time to union was 4.58 ± 1.06 months. A contributing factor to the delayed union in some cases may have been the presence of multiple injuries in 10 patients. Polytrauma is associated with

extended healing times due to systemic inflammatory responses, impaired bone metabolism, and increased physiological stress. Furthermore, patients with multiple injuries often experience restricted mobilisation and prolonged recovery periods, which can delay fracture consolidation and elevate the risk of complications. Only one case (2.50%) of malunion was reported. Overall, complication rates were low, with no reported cases of nonunion, delayed union, or radial nerve palsy, indicating that most patients experienced satisfactory healing without major complications (Table 5).

**Table 4.** Modified Stewart & Hundley classification of the enrolled patients

Modified Stewart & Hundley classification	At 6 weeks	At 3 months	At 6 months	p-value
Excellent	0	5	10	X = 33.81 p < 0.0001*
Good	7	11	21	
Fair	23	20	8	
Poor	10	4	1	

Source: compiled by the authors

**Table 5.** Time to union and complications among enrolled patients

Time to union and complications	Frequency	%
Mean time to union (months)	4.58 ± 1.06	
<b>Post-operative complications</b>		
Nonunion	0	0.00
Delayed union	0	0.00
Superficial infection	0	0.00
Deep infection	0	0.00
Malunion	1	2.50
Radial nerve palsy	0	0.00

Source: compiled by the authors

The current study recorded an average age of 32.64 ± 4.77 years, with a predominantly male population (65%). The most common age group was 26-30 years (37.50%). Consistent with Deepak *et al.* [11], humeral shaft fractures were more frequent among young and middle-aged individuals, with a male predominance. The average age aligns with the findings of R.V. Griend *et al.* [12],

although H.T. Hee *et al.* [13] reported a slightly higher average. In contrast to G.M. Sharma *et al.* [14], the gender distribution in the present study also indicates male predominance. Fracture classifications included 42.50% Type A, 27.50% Type B, and 30% Type C, similar to findings by Ş. Yiğit [15]. Both studies found consistent injury mechanisms and AO classifications across populations.

The present study found that 70% of injuries involved the right limb and 30% the left, differing from C.D. Deepak *et al.* [11], who reported equal proportions. Road traffic accidents accounted for 65% of fractures, consistent with findings by F.S.L. Meekers & P.L.O. Broos [16]. Similarly, G.M. Sharma *et al.* [14] noted dominant-side involvement in 62.7% of cases, with road traffic accidents accounting for 55.8%, supporting the present findings. The present study illustrates notable improvements in the range of motion following rehabilitation, with shoulder abduction/adduction increasing from  $150.12 \pm 10.34$  degrees to  $162.45 \pm 5.67$  degrees, shoulder flexion/extension from  $141.56 \pm 12.45$  degrees to  $150.90 \pm 8.87$  degrees, and elbow flexion/extension from  $130.89 \pm 10.98$  degrees to  $140.23 \pm 6.34$  degrees. M. Ghrairi *et al.* [17] found higher internal and external rotation torque peaks in male judo athletes, which aligns with the present study across genders, albeit with variations in assessment speed and normalisation methods. The use of normalisation techniques and alternative testing positions in the current study may explain the higher dominant-side ratios observed, compared to the seated-testing approach employed by M. Ghrairi *et al.* [17]. F.B. Marcondes *et al.* [18] also observed stable external/internal rotation ratios in female judo athletes, further supporting the present findings. However, P. Drid *et al.* [19] reported no significant differences between dominant and non-dominant sides in European judo athletes, which contrasts with the present study's minor asymmetries. Furthermore, comparisons with athletes in other sports, such as water polo and baseball, revealed distinct torque distribution patterns, highlighting sport-specific training adaptations. This aspect is recognised as a limitation of the present study.

Using the Modified Stewart & Hundley classification, this study showed notable improvements in patient outcomes over time. Initially, no patients had excellent outcomes at 6 weeks, but by 3 months, 5 patients achieved excellent outcomes, increasing to 10 at 6 months. Overall, significant improvement was observed ( $p < 0.0001$ ). G.M. Sharma *et al.* [14] reported 18.6% achieving excellent results, 62.8% good, 13% fair, and 4.65% poor outcomes. In the initial treatment phase, 60.00% of the 40 patients were treated with a U-slab, 7.50% underwent debridement, and 32.50% received alternative treatments. The average duration of surgery was  $148.00 \pm 13.47$  minutes, with an average blood loss of  $217.00 \pm 43.22$  mL, indicating significant surgical intervention. In contrast, Ş. Yiğit [15] reported shorter intervals from fracture to surgery (5.9 days vs 57.4 days), reduced operative times (92.2 minutes vs 119.2 minutes), and lower blood loss (281.2 mL vs 377 mL) in patients who underwent primary surgical treatment compared with those managed conservatively, although bone grafting rates were similar. These differences underscore the variability in treatment strategies and outcomes across studies.

The study demonstrated promising outcomes with a mean time to union of  $4.58 \pm 1.06$  months. Notably, no cases of nonunion, delayed union, superficial infection,

deep infection, or radial nerve palsy were observed, resulting in an incidence rate of 0.00% for these complications. Comparatively, M.D. McKee *et al.* [20] found a nonunion incidence of 2-4%, while Sarmiento *et al.* [5] reported a 5% rate of delayed union. Infections were also lower in the present study compared with the 1-2% superficial and 1% deep infection rates documented by J.W. Mast *et al.* [21]. Only one case of malunion (2.50%) was reported, which is favourable compared with the 5% rate noted by L. Klennerman [22]. Overall, the study's outcomes indicate a lower complication rate and effective management of humeral shaft fractures using DCP, consistent with or superior to previously reported literature. According to S. Raghavendra & H.P. Bhalodiya [23], approximately 11.8% of individuals experience radial nerve palsy following humeral shaft fractures. C.D. Deepak *et al.* [11] reported a 5% incidence of superficial infection following surgical treatment with DCP, which was managed with standard dressing and antibiotics, resulting in successful recovery within two weeks.

Thus, in the present study, significant improvements in the range of motion and functional outcomes were observed during follow-up, with an optimal time to union and low complication rates, including no cases of nonunion, delayed union, or radial nerve palsy. These findings demonstrate the efficacy of DCP fixation in achieving favourable alignment, rapid recovery, and reduced complications, supporting its reliability for the management of humeral shaft fractures.

## Conclusions

The present study highlights the effectiveness of DCP fixation in the treatment of humeral shaft fractures, particularly in a male and predominantly youthful population. The results indicate that this surgical method not only ensures precise fracture alignment but also enhances functional outcomes and range of motion during the follow-up. Based on the Modified Stewart & Hundley classification, the majority of patients achieved excellent or good outcomes, while others experienced a steady and substantial recovery. The effectiveness of DCP fixation in facilitating timely recovery was evident in the average time to fracture union of 4.58 months, which was well within the anticipated parameters. It is important to note that the study reported minimal complications, with only one instance of malunion and no cases of nonunion, delayed union, infections, or radial nerve palsy. The safety and reliability of this method in surgical management are emphasised by the low complication rate. Moreover, the research underscores the significance of individualised treatment strategies, particularly for youthful and active individuals who prioritise early mobilisation and functional restoration. The absence of major complications and the substantial improvements in the range of motion across all measured joints indicate that DCP fixation is a highly reliable and effective option. These results are consistent with the current body of literature and offer substantial evidence to support the use of DCP fixation as the preferred treatment for humeral

shaft fractures. This approach ensures patients an optimal recovery, reduced complications, and an improved quality of life. Future research should focus on comparing DCP fixation with alternative surgical methods, such as intramedullary nailing or minimally invasive techniques, to determine the most effective approach for different fracture patterns and patient profiles. Additionally, long-term follow-ups are essential to assess the durability of functional outcomes and late complications. Studies involving larger, more diverse populations and incorporating advanced imaging or biomechanical analyses may provide deeper

insights into optimal fixation strategies and tailored treatment protocols for humeral shaft fractures.

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### Conflict of Interest

None.

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## **Внутрішня фіксація перелому діяфіза плечової кістки динамічною компресійною пластиною: проспективне дослідження**

### **Аріндам Бхол**

Молодший резидент  
Меморіальний інститут медичних наук доктора КНС  
225001, дор. Файзабад, W45R+7X7, м. Барабанкі, Індія  
<https://orcid.org/0009-0008-3082-9684>

### **Супрія Такур**

Молодший резидент  
Меморіальний інститут медичних наук доктора КНС  
225001, дор. Файзабад, W45R+7X7, м. Барабанкі, Індія  
<https://orcid.org/0009-0000-1279-1928>

### **Пратік Деванган**

Молодший резидент  
Меморіальний інститут медичних наук доктора КНС  
225001, дор. Файзабад, W45R+7X7, м. Барабанкі, Індія  
<https://orcid.org/0009-0004-5432-1309>

### **Вішал Кумар**

Старший резидент  
Меморіальний інститут медичних наук доктора КНС  
225001, дор. Файзабад, W45R+7X7, м. Барабанкі, Індія  
<https://orcid.org/0009-0008-6467-0923>

### **Паріджат Гупта**

Професор, завідувач кафедри ортопедії  
Меморіальний інститут медичних наук доктора КНС  
225001, дор. Файзабад, W45R+7X7, м. Барабанкі, Індія  
<https://orcid.org/0009-0001-2712-4076>

**Анотація.** Лікування переломів плечової кістки є складним завданням через її унікальні анатомічні та біомеханічні характеристики. Фіксація динамічною компресійною пластиною є широко розповсюдженим методом хірургічного лікування таких переломів, спрямованим на досягнення стабільної фіксації та сприяння ранній мобілізації. Метою цього дослідження було оцінити клінічні та функціональні результати фіксації динамічною компресійною пластиною при переломах плечової кістки. Проспективне дослідження включало 40 пацієнтів зі зміщеними переломами плечової кістки, в тому числі з відкритими переломами I та II ступенів. Передопераційне обстеження включало клінічне обстеження та рентгенографічні дослідження. Хірургічна фіксація виконувалась за допомогою динамічної компресійної пластини, а післяопераційне спостереження проводилось через 2 тижні, 6 тижнів, 3 місяці та 6 місяців. Функціональні результати оцінювались за модифікованою класифікацією Stewart & Hundley, також було проведено статистичний аналіз. Середній вік досліджуваної когорти становив 32,64 років ( $\pm 4,77$ ), серед пацієнтів переважали чоловіки (65 %). Найчастішою причиною травм були дорожньо-транспортні пригоди (55 %). Переломи типу А були найчастішими (42,5 %),

причому 70 % стосувалися правої верхньої кінцівки. Середній час до зрощення становив  $4,58 \pm 1,06$  місяця. Через 6 місяців 10 пацієнтів мали відмінний результат, 21 – добрий, 8 – задовільний і 1 – поганий ( $p < 0,0001$ ). Передопераційні ускладнення включали множинні травми. Післяопераційні ускладнення були мінімальними, повідомлялося лише про один випадок незрощення. Отримані дані свідчать про те, що фіксація динамічною компресійною пластиною є ефективним методом лікування переломів плечової кістки, який демонструє значне покращення вирівнювання та функції, з низьким рівнем ускладнень та кращим часом зрощення. Ці результати підтверджують надійність динамічної компресійної пластини в оптимізації підходів до лікування та покращенні результатів лікування пацієнтів

**Ключові слова:** хірургічна фіксація; загоєння переломів; ортопедична хірургія; клінічні результати; діапазон рухів