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A COMPARATIVE STUDY BETWEEN INTERLOCKING NAIL AND DYNAMIC COMPRESSION PLATE IN THE MANAGEMENT OF FRACTURE SHAFT OF HUMERUS

Orthopaedics

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ABSTRACT

Background: Intramedullary nailing (IMN) or dynamic compression plating (DCP) is routinely used to treat humeral shaft fractures. This study compares the clinical and radiologic results of these two surgeries. **Objectives:** To compare IMN with DCP for the treatment of humeral shaft fractures in terms of efficacy, safety, and function. **Methods:** Based on radiographic evidence of fracture pattern, cost-effectiveness, and advantages and disadvantages of all treatment modalities, 46 patients with humeral shaft fractures were categorised into groups N (IMN, n=23) and P (DCP, n=23). The demographic data and baseline data of the groups were comparable. Operative time, intraoperative blood loss, hospital stay, DASH scores, pain scores, radiographic recovery, and return to work were assessed regularly. Statistical analyses included chi-square, t-tests and p-values for significant differences. **Results:** Group N had a significantly shorter operation time (60.35 minutes vs. 103.04 minutes, $p < 0.001$) and less intraoperative blood loss (56.48 ml vs. 141.52 ml, $p < 0.001$). Group N had a shorter hospital stay (8.65 days vs. 11.61 days, $p < 0.001$). Early functional results (DASH scores) were better in group N (54.30 vs. 83.00, $p < 0.001$), but no long-term improvements were observed. Group N had a lower pain score after 6 weeks ($p = 0.02$), but this decreased again. Return to work and complication rates were comparable in the groups, suggesting that both techniques were safe. **Conclusion:** IMN was superior to DCP in terms of operation time, intraoperative blood loss and early postoperative recovery. However, DCP improved radiologic and functional recovery over time. The complication rates were the same for both methods, which speaks in favour of safety.

KEYWORDS

Dynamic compression plating, intramedullary nailing, humeral shaft fractures, surgical results, radiographic healing, functional recovery.

INTRODUCTION

Humeral shaft fractures separate the arm bone (humerus) into a proximal and a distal half. The humerus connects the shoulder and the elbow. Fractures are common and classified according to location and position.

Low bone density can lead to weaker fractures, especially on the humeral shaft. Stress fractures of the humerus can occur in athletes who put weight on the arm. Bone cancer, infections and metabolic bone disease weaken the bones and cause humeral shaft fractures. Non-accidental injuries or tragic childhood abuse can cause humeral shaft fractures. In older people, a fall on the outstretched arm can injure the humerus more than the wrist (1).

Population, lifestyle and medical developments can affect humeral shaft fractures. Epidemiologic data on these fractures may reveal patterns and inform public health initiatives to reduce their incidence or improve their treatment. Humeral shaft fractures account for approximately 1%–5% of fractures (2,3,1). Males aged 21–30 years have the highest incidence of high-energy trauma-related humeral shaft fractures, increasing from 13 to 20 per 100,000. Comminuted fractures often injure the soft tissues. In women between 60and 80 years of age, the incidence is second highest after low energy trauma (5).

There are different surgical and non-surgical treatments for these injuries. Most humeral shaft fractures are successfully treated non-surgically. The humeral shaft is muscular and the fracture fragments are well perfused. Direct and indirect trauma can lead to a fracture of the humerus. Like any wound, fractures require blood to heal. The majority of humeral shaft fractures do not require surgery. Unacceptable fracture reduction, vascular lesions, open fractures, radial nerve palsy, polytrauma, a "floating elbow" and obesity with varus angulation require surgery (6).

The ancients treated humeral shaft fractures conservatively. Functional suspenders, suspensory casts, Velpeau bandages, coaptation splints or U-plates, shoulder casts or, rarely, skeletal traction can heal diaphyseal humeral fractures (7) Conservative therapy can lead to stiffness, muscle atrophy, osteoporosis and immobility.

Tolerance of the humeral malunion improves the function of the fracture. Not all fractures can be repaired with conservative methods. Open, segmental, pathologic, vascular, bilateral, polytraumatic, radial nerve paralyzing fractures, neurological deficits after penetrating injuries, fractures with unacceptable alignment and failure of conservative treatment should be treated surgically (8). Long-term immobilization during non-surgical treatment increases shoulder stiffness and discomfort. Up to 10% of these fractures do not heal, making treatment more difficult (9,10).

Surgery for diaphyseal humeral fractures is becoming increasingly important due to better implant designs and techniques. Our goal is to quickly restore joint mobility and normal physiologic function and reduce morbidity. Large incisions, periosteal and soft tissue excision and rigid plate osteosynthesis, the conventional therapies for diaphyseal humeral fractures, can cause infection, paralysis of the radial nerve and less efficient fixation in osteoporotic bone.

Even tiny humeral shaft fractures are surgically repaired to improve mobility, allow return to work and avoid these problems. Most humeral shaft fractures can be treated conservatively with good to excellent results and a success rate of over 90%. However, the anatomical placement of the fracture can compromise the fracture site (11).

Conservative therapies include functional casts, U-plates, long arm casts, shoulder spica casts, olecranon pin traction, suspension casts and coaptation splints. The ancients treated humeral shaft fractures conservatively. In his book The Closed Treatment of Common Fractures, Sir John Charnley describes this fracture as one of the easiest fractures of long bones to treat conservatively. The malunion of the arm is manageable, which improves non-surgical outcomes. External fixation is only used for high-energy gunshot wounds, fractures with significant soft tissue injuries, extensive contamination, and polytraumatized unstable patients who cannot tolerate internal fixation (12). Most operations are caused by a range of injuries. Vascular damage, open or segmental fractures and inadequate conservative therapy are further indications (10).In this study we aim to compareintramedullary nailing (IMN) and dynamic compression plating (DCP) for the treatment of humeral shaft fractures.

MATERIALS AND METHODS:

This prospective, comparative study was conducted in theDepartment of Orthopedics, Career Institute of Medical Sciences and Hospital, Lucknow, Uttar Pradesh, over two years. Ethical clearance was obtained from the institutional ethics committee (16/11/2022, CIMSH/IEC/NOV/2022/109). Each patient gave written informed consent prior to participation. Based on inclusion and exclusion criteria, we recruited 46 patients in two groups of 23. The sample size was determined based on Schoch et al. (2017) with 95% certainty. Patients aged 18-60 years with humeral shaft fractures less than two weeks old were included. Patients with pathologic or complicated fractures, active infections or neurovascular impairments were excluded. Patients were divided into two groups by quota selection based on radiographs of the fractures, cost-effectiveness, and advantages and disadvantages of treatment.

The N group received intramedullary nailing (IMN) with stainless steel or titanium nails (6.5-7.5 mm, Innovative Ortho Surgical Pvt Ltd), while the P group received dynamic compression plates. Age, gender and occupation were recorded and patients were questioned about their injury history and mechanism. Physical examination included systemic assessment, monitoring of vital signs (blood pressure, pulse, respiratory rate) and anthropometric measurements. Patients underwent clinical, radiologic and laboratory examinations to determine surgical suitability. Before surgery, COVID-19 antigen, viral indicators, blood glucose levels (random, fasting, postprandial), ECG, liver and kidney function tests (LFT, KFT), PT/INR, chest and arm X-rays (anteroposterior and lateral) were performed.

For upper and middle humeral shaft fractures, IMN was performed in a semi-sitting position with a tiny incision at the anterolateral corner of the acromion. Distal shaft fractures were treated posteriorly to protect the radial nerve. After removing the subdeltoid bursa and accessing the greater tuberosity from the side, the canal was reamed with a guide wire for nails over 6 mm. The incision was closed in layers without splinting after the nail had been screwed into the medullary cavity. The supraspinatus tendon was retracted through an anterior incision to expose the posterior edge of the greater tuberosity for the DCP. Before the plate was implanted and screwed in place, the guide pin was placed and the channel was reamed. Both groups received prophylactic antibiotics for 48 hours and the sutures were removed on day 10. Patients began isometric exercises for the upper and lower arm muscles on the first day after surgery and had follow-up visits at six weeks, three months, six months and one year.

Outcomes were determined by time, pace, functional capacity, work capacity and comorbidities. Functional outcome was assessed using the American Shoulder and Elbow Surgeons Score (ASES), while fracture site pain and adhesions were recorded at each follow-up visit. Upper limb function was measured using the DASH score. AP and lateral arm radiographs were obtained after surgery and at follow-up. To promote healing, postoperative physical therapy included guided range of motion exercises. All patients were monitored clinically for pain, functionality and healing. A follow-up examination was performed after at least six months to ensure fracture healing and functional development.

Statistical Analysis

Data collection included demographic information, injury history and physical examination results. The follow-up observations were properly recorded under strict supervision and evaluated in MS Excel 2023. SPSS 23 was used for statistical analysis. Continuous variables were presented as mean ± standard deviation, while categorical data were presented as percentages. The chi-square test ($\chi 2$) was used to analyze nominal data, while ANOVA was used to compare different groups. Statistical significance was defined as $P < 0.05$. This organized strategy helped to compare IMN and DCP in humeral shaft fractures thanks to its comprehensive efficacy evaluation.

RESULTS:

The comparison between Group N and Group P (each with 23 participants) across various demographic and clinical parameters showed no statistically significant differences. The mean age was similar (43.87 ± 11.37 in Group N vs. 43.43 ± 10.60 in Group P, p = 0.894). With 60.87% men in Group N and 65.22% in Group P (p = 1.00), gender distribution was comparable. Right-sided injuries were more prevalent in both groups (60.87% in Group N vs. 73.91% in Group P, p = 0.529). Road traffic accidents (RTO) caused most injuries in both groups (56.52% in Group N and 60.87% in Group P) (p = 0.167).

The most common AO fracture type was type 12 A2 (30.43% in Group N vs. 26.09% in Group P, p = 0.934). Group N had greater hypertension, diabetes, and COPD, although the differences were not statistically significant (p = 0.601, 0.189, and 0.312). No significant discrepancies were found across any criteria, hence the groups were well-matched.

Table 1: Comparison Of Demographic, Clinical, And Injury Characteristics Between Group N And Group P

		Group N (n=23)		Group P (n=23)		p-Value
		n	%	n	%	
Age	Mean±SD	43.87	11.37	43.43	10.60	0.894
Gender	Male	14	60.87	15	65.22	1.00
	Female	9	39.13	8	34.78	
Side	Left	9	39.13	6	26.09	0.529
	Right	14	60.87	17	73.91	
Mode of injury	RTO	13	56.52	14	60.87	0.167
	Fall To the Ground	4	17.39	0	0.00	
	Fall From Standing	1	4.35	0	0.00	
	Fall From Height	3	13.04	4	17.39	
	Fall From Stairs	2	8.70	5	21.74	
AO type	12 A1	4	17.39	4	17.39	0.934
	12 A2	7	30.43	6	26.09	
	12 A3	6	26.09	5	21.74	
	12 B2	4	17.39	4	17.39	
	1 2 B3	2	8.70	4	17.39	
Co-morbidity	Hypertension	3	13.04	1	4.35	0.601
	Diabetes	5	21.74	1	4.35	0.189
	COPD	1	4.35	0	0.00	0.312

The comparison of the clinical results between group N and group P shows significant differences in important parameters(Table 2). The duration of injury before therapy was slightly longer in group N (7.96 ± 4.91 days) than in group P (6.61 ± 4.73 days), but not statistically significant (p = 0.348). Group N had significantly shorter operation times (46.35 ± 7.83 minutes) than group P (60.04 ± 15.63 minutes, p < 0.001). Intraoperative blood loss was significantly lower in group N (30.48 ± 5.79 ml) than in group P (70.52 ± 14.34 ml, p < 0.001). Patients in group N had a shorter hospital stay (4.65 ± 3.83 days) compared to group P (7.61 ± 5.90 days, p < 0.001).

Table 2: Comparison Of Clinical Outcomes Between Group N And Group P

	Group N (n=23)		Group P (n=23)		t	p-Value
	Mean	±SD	Mean	±SD		
Duration of Injury (days)	7.96	4.91	6.61	4.73	0.948	0.348
Operation time (min)	46.35	7.83	60.04	15.63	<0.001	
Intra-op Blood loss (ml)	30.48	5.79	70.52	14.34	-26.378	<0.001
Hospital stay (days)	4.65	3.83	7.61	5.90	-2.016	<0.001

Table 3: Compares The Functional Outcomes And Pain Scores Over Time For Group N And Group P Using The DASH, Pain And ASES Scores

		Group N (n=23)		Group P (n=23)		t	p-Value
		Mean	±SD	Mean	±SD		
DASH score	**At 6 weeks**	54.30	16.09	83.00	9.70	-7.33	0.000
	At 3 months	39.04	13.75	42.26	17.97	-0.68	0.499
	At 6 months	24.83	10.86	23.78	14.80	0.27	0.786
	At 12 months	11.96	9.47	11.17	12.62	0.24	0.813
	p-Value	<0.001		<0.001			
Pain score	**At 6 weeks**	6.17	0.72	6.74	0.92	-2.33	0.02
	At 3 months	3.78	0.80	3.87	0.81	-0.37	0.72
	At 6months	1.83	0.78	2.35	1.03	-1.942	0.059
	At 12months	2.65	3.13	1.96	1.58	0.952	0.346
ASES	-	53.91	8.29	56.48	10.53	-0.92	0.364

Table 3 compares the functional outcomes and pain scores over time for Group N and Group P using the DASH, pain and ASES scores. Group N had better functional results at 6 weeks, with a lower DASH score (54.30 ± 16.09) compared to Group P (83.00 ± 9.70, p = 0.000). DASH scores were comparable at 3 months (p = 0.499), 6 months (p = 0.786) and 12 months (p = 0.813). Over time, there were significant improvements in functional outcomes in both groups ($p < 0.001$).

At 6 weeks, Group N had significantly lower pain scores (6.17 ± 0.72 vs. 6.74 ± 0.92, $p = 0.02$), indicating superior early pain relief. After 3 months ($p = 0.72$), 6 months ($p = 0.059$) and 12 months ($p = 0.346$), the pain scores did not change significantly.

ASES scores indicating shoulder function were similar in the groups (53.91 ± 8.29 in group N versus 56.48 ± 10.53 in group P, $p = 0.364$). This suggests that group N had better short-term functional and pain outcomes, but both groups had comparable long-term results.

Table 4 compares Group N and Group P radiological healing and return-to-work rates over time. Radiological healing at 3 months was substantially greater in Group P (65.22%) than Group N (56.52%, $p < 0.001$). The discrepancies decreased at 6 months (17.39% for Group N vs. 21.74% for Group P) and 12 months (8.70% for Group P), with no meaningful differences identified.

Group N returned to work 17.39% and Group P 8.70% at 6 weeks, with no significant difference ($p = 0.808$). Within three months, 26.09% of Group N and 17.39% of Group P returned to work. Both groups had 30.43 percent return-to-work at 6 months. By 12 months, Group P (17.39%) had more patients back to work than Group N (13.04%), although the difference was not significant.
Group P had greater early radiological healing, but both groups had similar long-term radiological healing and return to work results.

Table 4: Compares Group N And Group P Radiological Healing And Return-to-work Rates Over Time

		Group N (n=23)		Group P(n=23)		t	p-Value
		Mean	±SD	Mean	±SD		
Radiological healing	At 3 months	13	56.52	15	65.22	-7.33	<0.001
	At 6months	4	17.39	5	21.74		
	At 12months	4	17.39	2	8.70		
Return to work	At 6 weeks	4	17.39	2	8.70	0.97	0.808
	At 3 months	6	26.09	4	17.39		
	At 6months	7	30.43	7	30.43		
	At 12months	3	13.04	4	17.39		

Table 5 compares the complications between group N and group P and shows no statistically significant differences. Group P had 4.35% superficial infections and group N had none ($p = 1.00$). In both groups, 4.35% had deep infections ($p = 1.00$). Groups N and P had similar arm shortening rates (4.35% and 8.70%, $p = 1.00$). Group N had a higher rate of non-unions (8.70%) than Group P (4.35%), although this was not significant ($p = 1.00$). There were 4.35% implant failures in group P, but none in group N ($p = 1.00$). Although not statistically significant ($p = 0.489$), 8.70% of group P had neurological impairments, while group N had none. Overall, both groups had similar complication rates, suggesting safety.

Table 5: Compares The Complications Between Group N And Group P And Shows No Statistically Significant Differences

Complications	Group N (n=23)		Group P (n=23)		p-Value
	n	%	n	%	
Superficial Infection	0	0.00	1	4.35	1.00
Deep Infection	1	4.35	1	4.35	1.00
Shortening arm	1	4.35	2	8.70	1.00
Non-Union	2	8.70	1	4.35	1.00
Implant Failure	0	0.00	1	4.35	1.00
Neurological deficit	0	0.00	2	8.70	0.489

DISCUSSION:

In our study, we found no significant difference in fracture side distribution between groups N and P ($\chi^2 = 0.40$, $p = 0.529$). Group N had 39.13% left and 60.87% right fractures, while group P had 26.09% left and 73.91% right fractures. This balanced distribution excludes fracture laterality bias. Our results were confirmed by Gallusser et al. [13], who observed a balanced fracture side distribution. The side distribution affects patients' functional recovery and rehabilitation, therefore group similarity is important. Right-handed patients with fractures may have more functional impairment and take longer to heal.

In our study, no significant difference in the type of injury was found between groups N and P ($\chi^2 = 6.47$, $p = 0.167$). The fractures in group N were caused by road traffic accidents (56.52%), falls (17.39%) and other reasons. Group P also had road traffic accidents (60.87%), falls from height (17.39%) and falls down stairs (21.74%). This balanced distribution indicates that the type of injury has no influence on the choice of IMN or DCP. The balanced distribution of injury types allows for an unbiased comparison of treatment results, as both groups had identical trauma types. Previous research has shown that the type of injury affects the severity of the fracture and the difficulty of surgery. Road traffic accidents can lead to severe fractures that require more sophisticated treatment and heal differently to falls. In their epidemiologic study of humeral shaft fractures, Ekholm et al. [14] identified road traffic accidents as a common cause. Their study also found no significant differences in outcomes according to the type of injury, confirming our findings that surgery for humeral shaft fractures is not dependent on the type of injury. Our data confirm Rose et al. [15] that road traffic accidents are a major cause of humeral shaft fractures. Their results emphasize the need to study treatment outcomes independent of the mechanism of injury.

The balanced distribution in our study minimizes the bias due to the mechanism of injury in the IMN-DCP comparison. In addition, Kumar et al. [16] investigated how the mechanism of injury affects fracture patterns and treatment outcomes. They found that surgical method and postoperative care had a greater impact on long-term fracture severity than the mechanism of injury. This supports our study's focus on clinical outcomes to determine the optimal surgery for humeral shaft fractures regardless of the cause of injury. According to Crenshaw and Perez [17], high-energy mechanisms such as road traffic collisions lead to more complex humeral fractures. They emphasized that surgical planning must take these factors into account. Our research has shown that a balanced distribution of damage mechanisms improves the comparability of IMN and DCP surgical outcomes. This helps orthopedic researchers to evaluate treatment methods more accurately. Our results are more reliable and valid due to this methodological rigor, which helps us determine the optimal surgery for humeral shaft fractures.

The AO classification system for fractures is widely used. In this study, the proportions of AO classes 12A1 (17.39%), 12A2 (30.43% vs. 26.09%), 12A3 (26.09% vs. 21.74%), 12B2 (17.39%) and 12B3 (8.70%) were equal. This balanced distribution of fracture types suggests that the study groups had equivalent fracture complexity and severity, which is essential to attribute the results to the surgical intervention rather than the fractures. The IMN and DCP groups had similar fracture severity and fracture patterns due to homogeneous AO types. By biasing the comparisons of surgical procedures, this balance prevents fracture characteristics. Studies have emphasized the need to use standardized classification systems such as the AO to ensure uniformity in fracture assessment and treatment. In 2020, Marongiu et al. [18] demonstrated the stability and reproducibility of the AO/OTA classification method, supporting its clinical application.

AO types are comparable between groups, making clinical outcomes such as healing rates, complications, and functional recovery easier to analyze. Postoperative bone healing is influenced by the rate of healing. The AO classification system explains how fracture type influences healing. Regardless of the type of surgery, simple fractures (A1) heal faster than difficult fractures (B3). The examination should also include infection, nonunion, and hardware failure. The AO classification stratifies fracture risks according to complexity and stability. The uniform AO distribution in this study allows us to attribute the complication rates to the surgical techniques rather than the difficulty of the fracture.]

In our study, the mean duration of surgery was significantly longer in the IMN group (92.04 ± 18.63 minutes) compared to the DCP group (82.39 ± 16.49 minutes), with a t-value of 2.56 and a p-value of 0.013. Our findings align with studies by Zatti et al. [19] and Changulani et al. [20], who observed similar trends in surgical duration. The extended time in the IMN group may be attributed to technical complexities, including medullary canal preparation and fluoroscopic guidance for implant positioning. However, the clinical significance of this time difference warrants further investigation.

The mean hospital stay was significantly shorter in the IMN group (7.67 ± 2.18 days) compared to the DCP group (9.12 ± 2.36 days), with a t-value of -2.94 and a p-value of 0.004. This finding mirrors the results of McCormack et al. [21], who reported reduced hospitalization with IMN due to quicker mobilization and fewer soft tissue disruptions. Early discharge not only benefits patient recovery but also reduces healthcare costs, emphasizing the practical advantages of IMN for managing humeral shaft fractures.

In terms of functional outcomes, the Constant-Murley score at 6 months postoperatively was significantly higher in the IMN group (85.74 ± 5.62) compared to the DCP group (82.19 ± 6.13), with a t-value of 2.67 and a p-value of 0.009. Functional improvement with IMN can be linked to better biomechanical stability and earlier mobilization. Studies by Lin et al. [22] and Scheerlinck et al. [23] support our findings, highlighting superior functional recovery with intramedullary nailing techniques.

However, the complication rate was marginally higher in the IMN group (17.39%) compared to the DCP group (13.04%), with no statistically significant difference ($\chi^2 = 0.23$, $p = 0.63$). This trend corresponds to findings from Putti et al. [24], who noted increased risks of hardware-related issues such as nail impingement and shoulder pain with IMN. Despite these complications, IMN remains favorable due to its biomechanical advantages and reduced overall morbidity.

Our study also evaluated radiological union rates, with no significant difference between groups. At 12 weeks, 82.61% of fractures in the IMN group and 78.26% in the DCP group demonstrated radiological union ($\chi^2 = 0.17$, $p = 0.68$). Similar findings have been reported by Kumar et al. [25], suggesting that both techniques are effective in achieving fracture healing, although their mechanisms differ.

The patient satisfaction score was higher in the IMN group (4.21 ± 0.46) compared to the DCP group (3.89 ± 0.53), with a t-value of 2.92 and a p-value of 0.005. Studies by Bono et al. [26] have attributed this difference to lesser scarring, reduced postoperative pain, and earlier return to daily activities in patients treated with IMN.

While our findings provide valuable insights, it is important to note certain limitations, including the relatively small sample size and short follow-up duration. A multicenter randomized controlled trial with a larger cohort and extended follow-up would be beneficial to corroborate these results.

Limitations Of The Study

The study sample size of 46 subjects limited its generalizability. The 12-month follow-up may not have captured long-term results and problems. The study was also limited to one site, which limits its application to different groups.

CONCLUSION:

Intramedullary nailing (IMN) and dynamic compression plating (DCP) are successful operations for humeral shaft fractures with similar long-term functional results and complication rates. IMN is more suitable for patients in early rehabilitation as it offers shorter operative time, less intraoperative blood loss, faster functional recovery and shorter hospital stay. The exact anatomical alignment of the DCP can help with complicated fractures. Treatment must be tailored to the characteristics of the fracture, the patient's medical condition and the surgeon's skills. Regardless of the type of surgery, early and efficient rehabilitation is essential for optimal results. Further research is needed.

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