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A study of humerus shaft fractures treated with dynamic compression plating

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Abstract
Background and Objective: Management of humeral shaft fractures has historically been largely conservative. A significant body of literature has shown that functional bracing may achieve greater than 90% union rates and acceptable functional outcomes. More recently, however, with the advent of new surgical techniques and implant options, less tolerance for acceptable deformity and functional deficits, and less patience with conservative management, many treating orthopedic surgeons are increasingly likely to consider surgical intervention.The objective of this study is to assess the functional and radiological outcome of Humerus shaft fractures in adults treated by open reduction and internal fixation with Dynamic Compression Plate.
Materials and Methods: This study was done mainly as a prospective study with some data collected retrospectively among patients admitted for fracture shaft of Humerus at tertiary care hospital between August 2013 to July 2015. 30 patients underwent open reduction and internal fixation with dynamic compression plating. In our study we have used a scoring system invented by Dr. Rajiv N. Daveshwar for calculating result.
Results: Present study was comprises of 30 patients with humeral fracture with the mean age of 37.93 years and male/ female ratio of 5:1. Excellent result was seen in 22(73.34%) cases, 6(20%) cases had good results while fair result was found in 2 cases (6.66%). None of our cases showed poor results. Complications were seen in 5 patients of which 1 had non-union and 4 developed joint stiffness. Pre-operative traumatic Radial Nerve Palsy was found in 4 patients of which 2 recovered eventually while 2 did not.
Conclusions: It is concluded that internal fixation with plating is the good option for the fixation of diaphyseal Humerus fracture. Radial nerve palsy is less likely if isolated during operation.

Keywords: Humeral shaft fractures; dynamic compression plate; Radial nerve

Abbreviations: DCP – Dynamic Compression Plate; IMN – Intramedullary Nail; ORIF - Open reduction and Internal fixation; MIPO - Minimally Invasive Plate Osteosynthesis

1. Introduction
Humeral shaft fractures represent approximately 1-5% of all fractures [1-3]. There is a bimodal distribution with peaks primarily in young male patients, 21–30 years of age, and a larger peak in older females from 60–80 years of age [5]. The treatment approaches for these injuries continue to evolve as advances are made in both non operative and operative management [6]. Conservative management is not only important from a historical perspective, but also continues to be the mainstay of treatment for isolated humeral shaft fractures with overall good results. Numerous authors [11] have highlighted the advantages of conservative, gravity-dependent treatment of these fractures by bracing in ambulatory patients preceded by short period of traction [12]. However, non-surgical management is associated with some morbidity and complications have included nonunion, as high as 20% in some studies, malunion, and persistent radial nerve deficits [4, 7-10]. Operative treatment is indicated in specific circumstances including open fractures, associated neurovascular injury, proximal and distal articular extension, patients with multiple injuries or polytrauma, floating elbow, progressive radial nerve deficits, significant soft tissue injury (unable to brace), pathologic fractures and failed non-operative management [1, 9, 10].

More recently, the general patient as well as the treating orthopaedic surgeon is less tolerant of the more labor intensive methods of conservative management, and less tolerant of what was formerly thought to be acceptable deformity [3]. The encouraging outcomes that have been demonstrated with recent advances in internal fixation techniques and instrumentation have led to an expansion of surgical indications for humeral shaft fractures. There are new debates regarding the procedure of choice [13]. The purpose of this study to determine the efficacy of dynamic compression plate in closed diaphyseal humeral fracture in both gender along with postoperative complications and outcome.

2. Materials and Methods

Thirty consecutive patients operated with Dynamic compression plating for acute fractures of shaft Humerus during the period of August 2013 to July 2015 with minimum follow-up of 12 months were included in the present analysis. Both genders were included in the study. Patients with fractures of the proximal and distal Humerus and pathological fractures were not included in our study. Detailed Clinical examination of the patient along with all base line investigations were done and recorded in Performa.

During compression plating, we used the posterior approach in 28 patients and an antero-lateral approach was used in two patients. The choice of the approach was based on fracture position and morphology [figure 3]. A 4.5 mm compression plate (DCP (n = 20) and limited contact DCP (n = 7)) was used in all patients. Interfragmentary compression by means of lag screws was used when required. Generally, a plate that permitted screw fixation to at least six cortices both in the proximal and in the distal fragment was used [15].

Postoperatively all patients were initiated on active shoulder and elbow mobilization exercises. Periodic radiographic evaluation was carried out to look for union [16], to assess the need for additional procedures and to check for complications. All patients were evaluated on the basis of the outcome criteria [Annexure - 1].

Annexure 1: Dr. Rajiv N. Daveshwar scoring System

1. Shoulder Range of Motion

Flexion	
Up to 180°	4
150°-180°	3
130°-150°	2
100°-130°	1
<100°	0
Extension	
Up to 50°	4
40° – 50°	3
30° - 40°	2
20° - 30°	1
<20°	0
Abduction	
Up to 180°	4
150°-180°	3
130°-150°	2
100°-130°	1
<100°	0
Internal Rotation	
Up to 90°	4
70°-90°	3
60°-70°	2
50°-60°	1
<50°	0
External Rotation	
Up to 90°	4
70°- 90°	3
60°-70°	2
50°-60°	1
<50°	0

2. Score and Grading For Shoulder Range of Motion - Total Points 20

Grading	Score	Final Point
Excellent	16-20	3
Good	11-15	2
Fair	6-10	1
Poor	0-5	0

3. Deformity

Grading	Score
None clinically/Radiologically	2
none clinically : Minimal radiological deformity	1
marked : Clinical and radiological deformity	0

4. Elbow range of motion

Range of Motion	Score
Up to 150°	3
120°-150°	2
80°-120°	1
<80°	0

5. Union

Grading	Score
United	2
Delayed Union [12 weeks after surgery]	1
Non Union	0

6. Radial Nerve Palsy

Grading	Score
Absent or complete recovery	2
Partial recovery	1
No recovery	0

7. Functional assessment of patients

Function	Score
No restriction of activity	4
Minimal restriction; not impending daily activities	3
Restriction permitting daily activities with some difficulty.	2
Severe Restriction preventing or impending daily activities.	1
Total restriction	0

8. Final Score

Grading	Score
Excellent	13-16
Good	9-12
Fair	5-8
Poor	0-4

3. Results

Present study was done on 30 patients with humeral fracture, out of all patients male were found in the majority 83.34% as compare to the females 16.66% with male/female ratio of 5:1. Mean age of this study was 37.93 years. Most common age group was noted between 21-40 years of the age with the percentage of 60%, while 20% cases were documented with the age group of 41-60 years and only 13.33% cases were noted in the age group of 61-70 years. Fracture location was seen on left sides 33.33% and 66.67% on right side with right

to left ratio was 2:1.

Maximum (80%) patients in our study were labourers (manual and Farm). Most of patients had sustained fracture due to fall from height (53.33%) followed by RTA (40%). 28 patients (93.33%) had closed fracture while 2 patients (6.67%) had OG-I fracture. 21 patients (70%) had middle third fracture shaft Humerus while 7 patients (23.33%) had lower third fracture and 2 patients (6.67%) had upper third fracture. Out of type A and overall, A3 simple transverse was the most common variety. 20(66.66%) patients had isolated trauma while 10(33.33%) had associated injury of which head injury was the most common. 28(93.32%) patients were operated within first 2 weeks of trauma while 2 patients were operated after 2 weeks.

6 holes plate was commonest plate used in our patients 16 (53.33%) followed by 7 holes plate (5 patients {16.66%}). We used 6 screws (6 cortices each side) in 24(80%) patients followed by 8 screws (8 cortices each side) in 4 patients (13.33%). Interfragmentary screws were used in a 6(20%) patients. 28(93.33%) patients were immobilized with AE slab till suture removal after that mobilization of shoulder and elbow joint started. 2(6.66%) patients were given Humerus brace after suture removal whose fracture was fixed with LCP. Most of the patients (60%) were discharged on 6th post-operative day while 10 patients were discharged within 7-14 days.

All patients in our study achieved union except one. 14 of the fractures treated with compression plating achieved union within 12-14 weeks. 10 of the fractures achieved union within 14-16 weeks. The average time to union was 13.5 weeks. 1 patient had nonunion. 4(13.33%) patients had joint stiffness (2 had shoulder and 2 had elbow).

Radial nerve palsy [Figure - 1], [Figure - 2] was present in four patients after injury (13.33% incidence). Of the four patients who had undergone ORIF with compression plating with associated nerve injury, two had full recovery of function and one had partial but useless recovery of motor function and the third didn't recover and did not come for treatment after union of fracture. All these patients were found to have an intact nerve during preoperative exploration. There were no cases of postoperative radial nerve palsy plating.

The overall results according to the outcome score are given in [Table - 2]. Excellent results were seen in 73.34% of the cases, while 20% cases had good results and fair results were found in only 6.66% of the cases. We had not found poor functional results in any patient.

Fig 1: A case of Holstein Lewis fracture

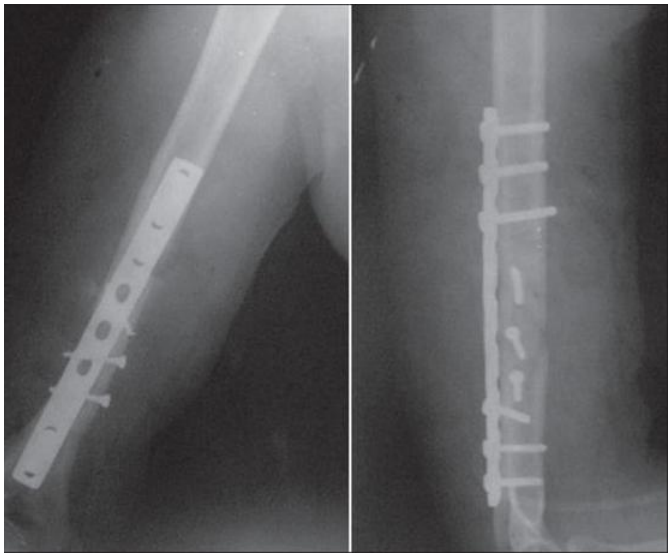

Fig 2: treatment of Holstein Lewis fracture with multiple Interfragmentary screws and compression plating

Fig 3

Three examples of different humeral shaft fracture stabilization options determined by the personality and location of the fracture. Posterolateral precontoured periarticular plate with lag screw fixation for a distal humeral shaft fracture through a posterior approach. Anterior humeral compression plating through an anterolateral approach for a simple, diaphyseal, short oblique fracture with minimal comminution. Intramedullary nailing for a comminuted proximal third humeral shaft fracture

Table 1: Classification of Fractures

Fracture Pattern		Patients	Percentage (%)
A. Simple fracture	A1-Simple spiral	8	26.67
	A2-Simple oblique ($\geq 30^0$)	4	13.33
	A3- Simple transverse $<30^0$	12	40
B. Wedge fracture	B1-Spiral wedge	0	0
	B2-Bending wedge	4	13.33
	B3-Fragmented wedge	2	6.67
C. Complex fracture	C1-Complex spiral	0	0
	C2-complex segmental	0	0
	C3-complex irregular	0	0
Total		30	100

Table 2: Results

Results	Patients	Percentage (%)
Excellent	22	73.33
Good	6	20
Fair	2	6.66
Poor	0	0
Total	30	100

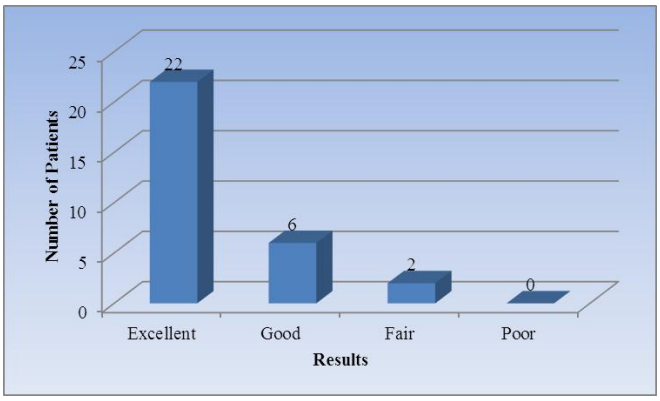

Fig 4

4. Discussion

4.1 Current concepts in non-operative versus operative intervention

Because the glenohumeral joint has an exceptional range of motion in many planes, deformity is well tolerated after union. Acceptable fracture alignment, which is the guide to continued conservative management, includes 20 degrees of anterior bowing, 30 degrees of varus angulation, 15 degrees of malrotation, and 3 cm of shortening or bayonet apposition [17]. Traditionally, nonoperative management of humeral shaft fractures is the mainstay of treatment although there can be some drawbacks. Treatment with functional bracing can lead to loss of some shoulder external rotation, flexion, and abduction in 10% to 30% of patients. Also, loss of elbow flexion and extension is impaired in less than 10% of patients [4, 18, 19].

Denard *et al* directly compared outcomes of nonoperative versus operative management of humeral shaft fractures in a retrospective study of 213 patients. They found a statistically significant difference in the occurrence of non-union (20.6% versus 8.7%) and malunion (12.7% versus 1.3%), more common in the nonoperative group. They demonstrated that operative intervention had no significant difference in time to union, infection, or iatrogenic radial nerve palsy. They concluded that with recent improvements in plating techniques and implants, acute surgical management of humeral shaft fractures should be considered; and that although functional bracing achieves acceptable results with few complications, the incidence of non-union and malunion may result in further operations with added morbidity to correct the problem [8].

4.2 Operative management of humeral shaft fractures

Absolute indications for surgical intervention in humeral shaft fractures are open fractures, associated neurovascular injury, proximal and distal articular extension, patients with multiple injuries or polytrauma, floating elbow, progressive radial nerve deficits, significant soft tissue injury (unable to brace), pathologic fractures and failed non-operative management. Other relative indications include (1) obese patients, who do not tolerate bracing well and frequently end up with coronal plane deformities; (2) patients with associated brachial plexus injuries due to the loss of muscle co-contraction and its ability to maintain bony alignment; and 3) non-compliant patients, who do not adhere to upright posture, elbow motion, and brace tightening instructions [4, 7].

External fixation is primarily used in damage-control situations where the patient is too unstable for more time consuming procedures. In such scenarios, the frame is constructed for temporary stabilization to facilitate wound care, patient transfers, line access, and pain control. These patients are frequently converted to internal fixation once hemodynamics and associated injuries have improved. Additional indications for external fixation application include severe soft tissue injuries, vascular injuries requiring quick stabilization before repair, and an unstable elbow joint after bony fixation [20-22].

Compression plating has been regarded as the gold standard for operative treatment with high rates of fracture healing, lower reoperation rate, avoidance of adjacent joint discomfort and good outcome with no adverse effect of immediate full weight-bearing on fracture union or alignment [23]. There is substantial variability in plating that allows the surgeon to modify the construct to the personality of the patient and fracture. Simple fractures are best treated with compression plates, comminuted fractures are often bridge plated, and osteopenic or torsionally unstable fractures are candidates for locked or hybrid plate fixation [24]. Contemporary plates used in humeral shaft fractures are 4.5 mm limited-contact plates with combination holes to accommodate either cortical or locking screws. These plates come in narrow and broad varieties. Both have holes at the plate ends that allow use of an articulating tensioning device to provide fracture site compression. The broad plate has staggered holes to improve screw density and limit the development of stress risers. These robust plates allow early weight-bearing [25, 26].

Traditional plate fixation has the drawback of requiring larger incisions, violation of the fracture hematoma, and higher incidence of iatrogenic radial nerve palsy [3, 26]. In an effort to avoid these drawbacks, Minimally Invasive Plate Osteosynthesis (MIPO) has been developed for humeral shaft fractures indicated for fractures 6 cm below the surgical neck and 6 cm above the olecranon fossa, using the two-incision approach. In this procedure, a 10 to 12 hole narrow 4.5 mm plate is inserted submuscularly and provisionally stabilized through each incision [24]. Reduction is obtained through traction, arm manipulation, and sometimes temporary use of an external fixator frame or ender's nail. Three screws are then placed on each side of the fracture. This method protects the radial nerve and preserves fracture site biology. Potential drawbacks include brachial scarring and subsequent loss of elbow motion, difficulty obtaining an adequate reduction and resultant increase in radiation exposure and operative time, and risk of nerve injury with percutaneous screw placement [28].

Intramedullary nailing of humeral shaft fractures has the benefit of smaller incisions, preserved fracture site biology, and load sharing properties. [29, 30] Use of these implants, however, has been infrequent due to concerns of non-union, reoperation, stiffness, start site fracture, and adjacent joint pain [3, 26]. Interest in this mode of treatment has been renewed due to shifts in humeral shaft fracture epidemiology, implant design, and surgical technique. Intramedullary nails are currently the preferred mode of treatment for fractures with associated soft tissue injury, pathologic fracture, diaphyseal segmental fractures, and osteopenic bone. Humeral shaft fractures in elderly patients with poor bone quality is on the rise. These patients are best treated with a load sharing device. The load sharing properties have been augmented by

developments in nail design.

However, various authors have reported complications associated with intramedullary nailing of the shaft of the Humerus. The anatomical configuration of the shaft of the Humerus makes it prone for residual fracture site distraction, especially where the sagittal diameter of the distal part is small. Residual fracture site distraction can lead to increased risk of delayed union/non-union, with the need for additional procedures to obtain union.

Choosing to plate or nail a humeral shaft fracture is becoming more a matter of patient preference with potential complications and surgeon familiarity. A meta-analysis that previously favoured plating over nailing was recently updated and noted equivalent outcomes in rates of non-union, infection, nerve palsy, reoperation, and total complications between humeral plating and nailing [31]. With modern implants and surgeons adept to their use, humeral union and functional outcomes has been shown to be the same between plates and nails.**32** Implant selection should ultimately be based on patient factors, fracture personality, associated injuries, and surgeon preference [6]. Patients should be counselled about iatrogenic radial nerve palsy with plates and rotational malalignment and adjacent joint pain with intramedullary nails [33, 34].

4.3 Discussion of Present study

Present study was done on 30 patients with humeral fracture. Out of all patients male were found in the majority 83.34% as compare to the females 16.66%. The higher rate of fracture in male clearly correlates with the life style of male, mostly in Indian population. The males are more involved in outdoor activities and the young male are more enthusiastic about life and are careless drivers. Female usually have sedentary life style and less involved in driving which is a common cause. However the male to female ratio given by Mirdad TM [35] is 9.8:1, Reyes-Saravia GA [36] is 3.4:1. While in this study male/female ratio was of 5:1.

Mean age of present study was 37.93 years with maximum number of patients in 21-40 years of age group. Age group of the patients in the study of JPS Walia MS. *et al*., [37] were varied between 18-70 years with majority of the patients in fifth to seventh decade of life.

The most common cause of fracture shaft of Humerus in our study was road traffic accident (RTA). According to the study of Memon FA [38], 63.7% patient's had fractures and soft tissue injuries caused by road traffic accident and 36.2% were resulted of domestic fall. In another study by Putti AB [39], out of 34 patients the cause of the injuries leading to admission was RTA in 82.3%. The findings of present study matches these studies the road traffic accident is the most common cause of fracture shaft of Humerus.

On the radiological findings most common fracture pattern was Transverse. A study on humeral shaft by Olasinde Anthony Ayotunde *et al*, reported that the transverse fracture was the most common [40]. Ring D *et al*, [41] found that most common fractures oblique and spiral.

None of our patient had post-operative infection. However frequency of wound infection given by Bell *et al* [42] in a series of 33 patients treated with dynamic compression plate was 1(3%) case. Iatrogenic palsy of radial nerve, non-union, adhesive capsulitis and implant failure were seen in the cases 0%, 3.33%, 0% and 0% respectively. In the respective IMN and DCP groups rates reported of iatrogenic radial nerve palsy were 2.6 to 14.3% [43] and 2 to 5% [44, 45]. The incidence of nonunion reported in the literature is between 0–8% [46, 47]. In the study of Erwin Denies *et al*, [48] on humeral shaft fracture; he reported that 71.4% excellent results, in 20.9% good results and poor results in 4.4% which is comparable to present study except for poor results.

5. Conclusion

In the conclusion of this study, 30 patients of humeral shaft fractures that were treated by dynamic compression plate, fractures were found in young male cases and Road traffic accidents were seen in majority. The dynamic compression plate is the very good management method for treatment of fracture shaft of Humerus with very low rate of complications.

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