

Prospective Study of 30 Cases of Humerus Diaphyseal Fractures in the Adult Population

Tank Parag M¹, Damor Harshal N², Dave Dhruvil S³, Patel Dhaval V⁴, Vadera Tejas S⁵

¹Associate Professor, Department of Orthopaedics, Smt. NHL Municipal Medical College, Ahmedabad, Gujarat

²Assistant Professor, Department of Orthopaedics, Smt. NHL Municipal Medical College, Ahmedabad, Gujarat

³Assistant Professor, Department of Orthopaedics, Smt. NHL Municipal Medical College, Ahmedabad, Gujarat

⁴Resident doctor, Department of Orthopaedics, Smt. NHL Municipal Medical College, Ahmedabad, Gujarat

⁵Resident doctor, Department of Orthopaedics, Smt. NHL Municipal Medical College, Ahmedabad, Gujarat

Received: 20-04-2023 / Revised: 11-05-2023 / Accepted: 05-06-2023

Corresponding author: Tank Parag M

Conflict of interest: Nil

Abstract:

Background: Fractures of the humerus comprise 5% to 8% of all long bone fractures, of which diaphyseal fractures account for approximately 3%. With improved implant design and surgical techniques, the Operative management of diaphyseal fractures has been widely accepted. Re-establishing length, alignment, and rotation with stable fixation are the goals of operative intervention to allow an early range of motion and ease in continuing daily living activities. This study aims at studying the operative outcomes of diaphyseal fractures.

Methods: We included 30 patients treated with various operative techniques in the study. Operative techniques include open reduction internal fixation with plating and close reduction internal fixation with intramedullary nailing. Acute diaphyseal fractures of the humerus based on AO/OTA classification with a minimum of 6 months of follow-up are included. Proximal and distal intra-articular fractures are excluded. ASES score & Rodriguez Merchant criteria were used for functional outcome assessment.

Results: We had 53.4% had excellent and 40% had good results and 87% had no postoperative complication

Conclusion: Operative management of humeral diaphyseal fractures results in good to excellent functional outcomes with minimal complications. Despite improved implant design and better surgical techniques, Proper pre-operative planning and post-operative rehabilitation are more important to obtain excellent results.

Keywords: AO/OTA classification, Rodriguez Merchant criteria, ASES score, Fracture Humerus.

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Introduction

Humeral fractures are common long bone fractures that account for 5% to 8% of all extremity fractures. Based on anatomical location humeral fractures are divided into proximal, shaft, and distal humeral fractures. Humeral shaft fractures account for 3% of all long bone fractures. Although most humeral shaft fractures can be treated nonoperatively but with improved implant design and surgical technique, operative management of humeral shaft fractures has increasingly become accepted[1][2]. Fractures involving the middle 3/5th of the humerus, extending from the upper end of the insertion of pectoralis major to the supracondylar region distally are called humeral shaft fractures. Humeral shaft fractures occur in young adults because of high-velocity injuries like

road traffic accidents, falls from height, assaults, and heavy machinery injuries.

Historically humeral shaft fractures have opted for conservative treatment. With improved implant design and surgical techniques, operative management of humeral shaft fractures has increasingly become accepted. The goal of operative treatment of humeral shaft fractures is to re-establish length, alignment, and rotation with stable fixation that allows early motion and ideally early weight bearing on the fractured extremity.

The surgical management of humeral shaft fractures includes intramedullary flexible nails, intramedullary interlock nails, and plate fixation. Plate osteosynthesis with stable fixation and direct

visualization, which provide an accurate anatomical reduction can reduce the risk of malunion.

Open reduction and internal fixation by plate osteosynthesis for humeral shaft fracture can be done by anterolateral approach, posterior approach, or minimally invasive plate osteosynthesis.

Material and Method

We included thirty patients with humeral shaft fractures treated with various operative techniques. We undertook the study in our institute and collected data from all patients using a standard proforma between August 2020 to July 2022.

Inclusion criteria:

- Acute diaphyseal fractures of the humerus (within two weeks of injury) based on AO/OTA classification (12A1, 12A2, 12A3, 12B2).
- Patients older than 18 years.
- All operated cases of shaft humerus fractures with a minimum of 6 months of follow-up.
- Patients who are willing to give written and informed consent.

Exclusion criteria:

- Patients with a diaphyseal fracture below 18yrs of age.
- Proximal and distal humerus intra-articular fractures.
- Pathological diaphyseal humerus fractures.
- Compound diaphyseal fractures.
- Patients who are not willing to give consent.
- Patients lost to follow-up.

Approval to perform the study was sought and obtained from the Institutional review board. We took the patients in operation within 1-10 days when the patient's local and general condition permitted for definitive fixation. On admission, a complete clinical examination was done comprising Systemic and Local examinations-

- Swelling and deformity of the shoulder or elbow
- Check for circulatory status
- Sensation of shoulder and arm
- Condition of skin

The following treatment protocol for shaft humerus fracture was followed. Initial management was done with U slab till the patient is fit for surgery. Adequate analgesics either oral or parenteral were given to provide relief from pain After stabilization, the following investigations were conducted:

- Routine Blood Investigation
- X-rays: Shoulder with humerus with elbow-AP/Lateral, chest x-ray (routine)
- Electrocardiogram

A pre-anaesthetic evaluation was carried out and patients were taken up for surgery after obtaining informed written consent. Parenteral antibiotics were started on the night before surgery and continued thereafter.

We have done a prospective study of 30 patients with humeral shaft fractures treated with various operative techniques including open reduction-internal fixation by plates and close reduction-internal fixation by interlocking nails.

The patients were placed in a supine position on an operating table with the arm in abduction on the arm board. Supraclavicular block or General anesthesia is administered in all patients. Painting-draping was done on the affected arm.

A skin incision was marked beginning from the deltoid tubercle and continued distally just proximal to the antecubital crease. Superficial dissection was done. Fascia was split. A deep dissection was done. The interval between the biceps and the brachialis was identified. The musculocutaneous nerve and radial nerve were identified and protected with a vessel loop. Brachialis was split in line with the fibers between the medial 2/3 and the lateral 1/3. Thus fracture site was exposed and cleared by sharp periosteal dissection. Fracture fragments were identified. Fracture reduction was done using gentle traction and rotation under image intensifier guidance. Fracture reduction was maintained by using reduction clamps. Kirschner wires were used to fix the fracture provisionally. Plate length was determined under image intensifier guidance.

The plate was placed on the shaft of the humerus and held with a plate-holding clamp. 4.5mm cortical screws were placed through the holes that are proximal and distal to the fracture site, thus definitive fixation was done. Final placement was checked under the image intensifier. The stability of fixation was checked by rotating, flexing, and extending the arm.

The posterior approach was taken with a triceps splitting technique and fixation was done with standard protocol. Antegrade Nailing was done with the standard supraspinatus approach. (Figure 1)

Immediately after surgery, the shoulder is immobilized in a universal shoulder immobilizer. All the cases were given broad-spectrum I/V antibiotics and were continued for 5 days postoperatively for plate osteosynthesis after which the patient was switched to oral antibiotics. Analgesics if required were also given. Post-operative check radiographs were taken.

Depending upon the pain, pendulum exercises begin as soon as possible. In the first week passive range of motion started. Active range of motion

was started at 2-4 weeks postoperatively, depending on the stability of osteosynthesis. In the fourth to sixth week, immobilization is discontinued. Active assisted movements started up to 90° abduction with no forced external rotation. In the sixth to eighth week- a full range of movements with active exercises and full weight bearing started. Follow-up was scheduled at intervals of 2 weeks, 1 month, 3 months, and 6 months. X-rays were assessed clinically and radiologically. Functional outcome was evaluated at minimum 6 months of follow-up under Rodriguez Merchan criteria and American shoulder and elbow surgeon's scoring system.

Results

In our study of 30 cases of humeral shaft fractures treated with various operative techniques including open reduction internal fixation by plating and close reduction internal fixation by nailing, our youngest patient was 23 years old, and the oldest patient was 56 years old. In this study, we had a minimum follow-up of 6 months to maximum follow-up of 24 months. 16 (53%) patients were male and 14 (47%) patients were female. (Figure 2)

The age of the patients in the study ranged from twenty-three to fifty-six years, the average being 42 years. 40% of the total number of patients were from the 41-50 years age group.

We have seen that the majority of the patients (26) were operated within 5 days of injury. Only 4 patients were operated after 5 days of injury.

We have observed that a major number of cases of fracture humerus have a mode of injury through RTA. A total of 30 patients out of which 15 patients (50%) show injury due to RTA, 8 patients (26.7%) show injury due to fall from height and 7 patients (23.33%) show injury due to fall on the ground. We have seen that an equal number of patients show laterality of limb.

We classified fractures by AO/OTA classification (table 1). Out of 30 patients, 23 patients were classified into simple shaft fractures AO 12A including 5 patients of spiral fracture – 12A1, 9 patients of oblique fracture – 12A2, and 9 patients of transverse fracture – 12A3. Rest 7 patients were classified into wedge shaft fractures AO 12B includes 7 patients of intact wedge fracture – 12B2.

Humeral shaft fractures are classified by anatomic location into proximal 3rd, middle 3rd, and distal 3rd. In our study out of 30 patients, 22 patients (73.3%)

were classified as middle 3rd, 5 patients (16.7%) were classified as distal 3rd, and 3 patients were classified as proximal 3rd humeral shaft fracture.

Out of 30 patients, 20 patients (66.7%) had no associated injury. There was some degree of minimal injury to the ipsilateral limb and/or contralateral limb in the form of abrasion (23.3% - 7 patients) and laceration (10% - 3 patients).

Out of 30 patients, 16 patients (53.3%) were treated with open reduction internal fixation by plating and 14 patients (46.7%) were treated with close reduction internal fixation by IM nailing.

14 patients (46%) underwent close reduction internal fixation by IM interlocking nails. The remaining 16 patients (54%) were treated with open reduction internal fixation by plating of which we used a 3.5mm PHILOS plate for proximal 3rd in 2 patients (7%), 3.5mm distal humeral extra-articular LCP plate for distal 3rd in 5 patients (17%) and for middle 3rd humeral shaft fracture 4.5mm narrow DCP and LCP plates were used in 6 (20%) and 3 (10%) patients respectively. (Figure 3-4)

26 patients (87%) highest number of patients were seen having no complications after surgery.

3 patients (10%) show radiological union less than 12 weeks. 26 patients (87%) show radiological union between 12 to 26 weeks. In our study, only 1 patient (3%) show non-union for which we advised for bone grafting and re-plating but the patient refused for same.

53.4% of the total number of patients had a full range of motion at the shoulder.

17 patients (56.7%) had ASES Scores (table 2) between 91-100, 11 patients (36.7%) had scores between 81-90, 1 patient (3.3%) had a score between 71-80 and 1 patient (3.3%) had a score < 60. We had 93.4% excellent/good, 3.3% fair & 3.3% poor results.

16 patients (53.4%) had excellent functional outcomes, 12 patients (40%) had good, 1 patient (3.3%) had fair and 1 patient (3.3%) had poor functional outcomes (table 3).

Statistical Analysis: The functional outcome graded as Excellent, Good, Fair, and Poor on the basis of Rodriguez Merchan criteria and ASES score and a Chi-square test gave a p-value of <0.0001 indicating that there was statistical significance in the functional outcome of the two management modalities (table 4).



Figure 1: A 28years Old Male Patient With Left Sided Middle 3rd Humeral Diphyseal Fracture – AO 12A3 Treated With Close Reduction Internal Fixation By IM Interlocking Nail



Figure 2: Clinical And functional Outcome at final follow up



Figure 3: Clinical Follow up



Figure 4: A 30years Old Male Patient with Left Sided Middle 3rd Humeral Diphyaseal Fracture - AO 12A2 Treated With Open Reduction Internal Fixation by Plating

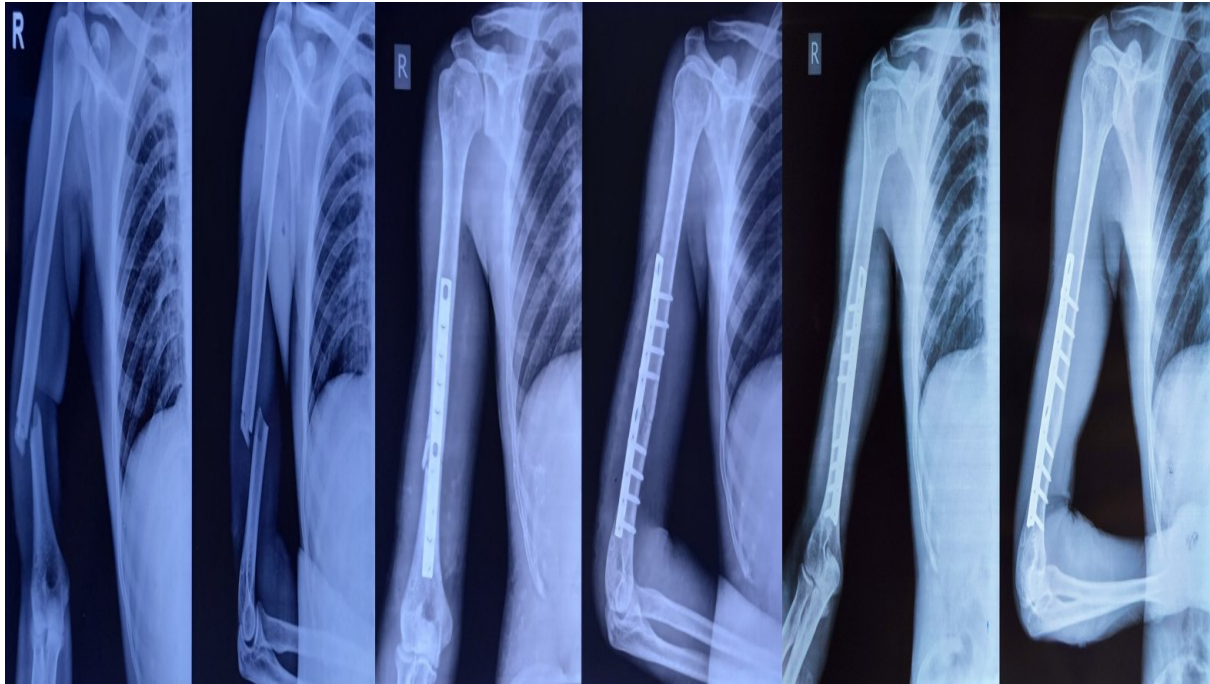


Figure 5: A 23 Years Old Male Patient with Right Sided Middle 3rd Humeral Diphyseal Fracture – AO 12A2 Treated With Open Reduction Internal Fixation with Plating



Figure 6: Surgical scar and final movement
Table 1: AO/OTA Classification

12A (Simple)	12A1 – Spiral	5
	12A2 – Oblique	9
	12A3 – Transverse	9
12B (Wedge)	12B2 – Intact Wedge	7
	12B3 – Fragmentary Wedge	0
12C (Multifragmentary)	12C2 – Intact Segmental	0
	12C3 – Fragmentary Segmental	0

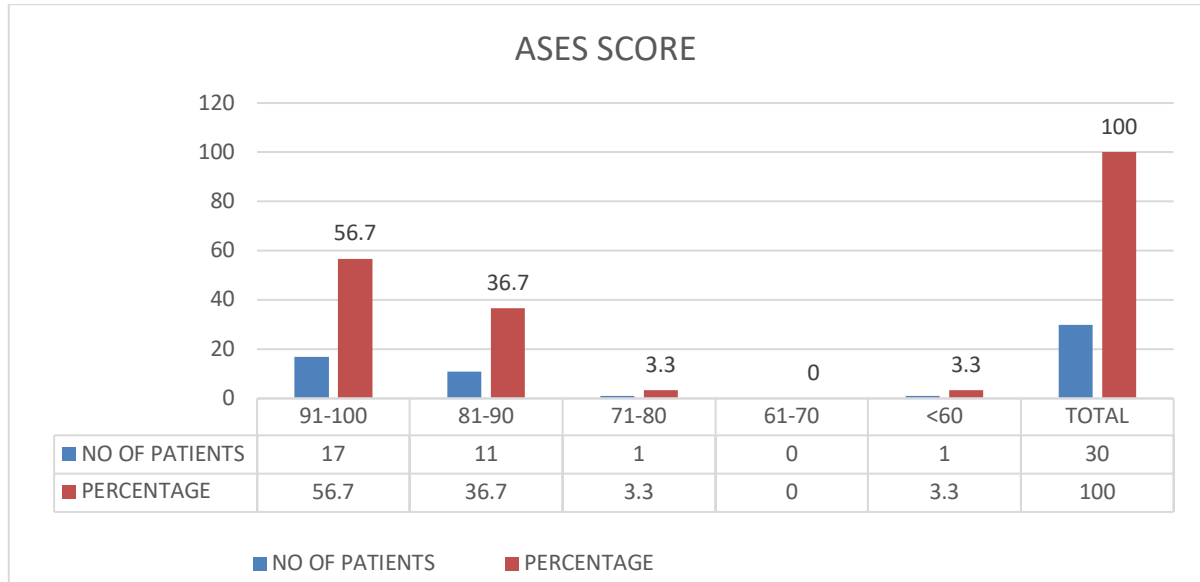


Figure 7: ASES Score-Wise Distribution of Patients

Table 2: Functional Outcome

Functional Outcome	No Of Patients	Percentage
Excellent	16	53.4
Good	12	40
Fair	1	3.3
Poor	1	3.3
Total	30	100

Table 3: Statistical Analysis

Study	Score & Outcome	P value
Wang Y et al	ASES score with mean score of 93.82	0.01
Bhuvanesh K et al	ASES score with mean score of 81.1	0.02
Present study	ASES score with mean score of 90.6	< 0.0001

Discussion

The humeral shaft fracture was treated with various operative techniques including open reduction internal fixation by plating and close reduction internal fixation by intramedullary nailing, we included 30 patients, ages 18-56 years with a mean age of 42 years. This indicates high rates of diaphyseal fractures in 5th decade of life. Several studies showed a similar pattern of age distribution which includes Raghavendra S et al [3] with a mean age of 40.53 years, McCormack RG et al [4] with a mean age of 44.5 years, Benegas E et al [5] with a mean age of 42.2 years and Shah SM et al [6] with a mean age of 41.6 years. 16 patients (53%) were male and 14 patients (47%) were female. Male to

female ratio was 1.14:1. Similar kind of observation has been described by Mouraria GG et al [7] (2:1) and Lin J et al [24] (1.5:1). In most studies, mostly male patients suffered from humeral diaphyseal fractures as a result of more outdoor activities, hence, more chances of roadside accidents and more work-related injuries. The mechanisms of injury included Road traffic accident with 15 (50%), fall from height with 8 (26.7%) and fall on the ground with 7 (23.33%). A road traffic accident was the most common cause of injury. While in the study conducted by Rommens et al [8], there were Road traffic accident, sports injury, and accident at home out of which Road traffic accident was the most common cause of injury. Our studies include Singiseti et al

[9] (85%) and Ricchetti et al [10] (53.8%) were also showed road traffic accidents most common cause of injury. 15 patients (50%) had right limb and 15 patients (50%) had left limb involvement. No obvious side predilection was noted by Singiseti et al [9]. We found that 66.7% of patients had no associated injury in our study. The incidence of associated injuries in our study was 33.3% which include abrasion in 23.3 % and laceration in 10% of patients. Unlike other studies, we had no neurological injury. In a study by Moradiya et al [11] associated nerve palsy was present in 13.33% of the patients after the injury.

The majority of the patients suffered from a humeral diaphyseal fracture at the level of middle 3rd (73.3%), distal 3rd (16.7%) followed by proximal 3rd (10%). A study conducted by Singiseti et al [9] involved 64% of the cases of middle 3rd humeral diaphyseal fracture. Wali et al [12] reported that the majority of the fractures were at the middle 3rd (52%), then distal 3rd (24%) followed by the proximal 3rd level. 30% of the total number of patients were in 12A2, whereas the other 30% were in 12A3, 16.7% were in 12A1 and 23.3 % were in the 12B2 category. All of those were treated with various operative techniques. In a study by Singiseti et al [9], all the fractures could be grouped as A3 and B2 of the AO classification.

53.3% of the total number of patients were treated with open reduction internal fixation by plating (plate osteosynthesis), and the rest 46.7% were treated with close reduction internal fixation with intramedullary interlock nailing (Naser MA et al [13]).

In our study for 17% of the total number of patients, we used a 3.5mm distal humeral extra-articular LCP plate (For distal 3rd fractures) (J Rajesh et al [14]), for 7% we used a 3.5mm long PHILOS plate (For proximal 3rd fractures), for 20% we used 4.5mm narrow DCP plate, for 10% we used 4.5mm narrow LCP plate and for 46% we used intramedullary interlocking nail (For middle 3rd fractures). 87% of the fractures united between 12-24 weeks following surgical intervention. 13% of fractures united in less than 12 weeks. Union did not occur in one patient. That patient was explained for re-plating by open reduction internal fixation and bone grafting. The patient refused and lost to follow-up. In this study mean union time was 15.06 weeks.

The union of bones in the study of Kumar et al [15] took an average of 12.2 weeks. The average union time in the study of Roomens et al [8] was 13.7 weeks. (Figure 3,5) 87% of the total number of patients were having no complications after operative intervention. Pain was the most common complication seen in 10% of patients which was managed by oral analgesics. One patient (3%)

presented with non-union which advised bone grafting and re-plating, the patient refused further intervention. Choudhary et al [16] showed no obvious complication except 1 patient (3.3%) with wound leakage in 2nd week. ASES score was used for shoulder function derived from self-reported visual analog score (50%) rating of pain and cumulative activities of daily living scores (50%), yielding a maximum score of 100. In our study mean ASES score of 90.6 ranges from 44 to 100. We had 93.4% excellent/good results and 6.6% fair/poor results. We have observed that Bell et al [23], Rodriguez et al [17], and Tingstad et al [18] studies had 92% good, 95% good, and 94% good/excellent results respectively. Rodriguez Merchan criteria were used to assess the functional outcome. We had 53.4% excellent, 40% good, 3.3% fair, and 3.3% poor functional outcomes.

Similar criteria were used in Singiseti K et al [9], Changulani et al [19], Kesemenli C et al [20], Denies E et al [21], Venkatesh Gupta S K et al [22] studies. (Figure 4-6) Strict adherence to the AO principles during fixation, meticulous attention to the maintenance of asepsis during surgery, patient education, and a well-planned rehabilitation program are required to obtain good results.

Ethical Approval: Received from NHL Institutional Review Board committee.

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