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A study of 40 cases of diaphyseal fracture of shaft of the humerus treated with plate osteosynthesis

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Abstract
Introduction: Different modalities of treatment are available for fracture shaft of humerus. It includes various conservative methods like immobilization in a sling, Thomas arm splint, U slab, hanging cast, shoulder spica cast and surgical treatment such as intramedullary nailing, plate osteosynthesis, and external fixator. These different methods have their own advantages and disadvantages. Method of plate osteosynthesis is sometimes associated with infection and iatrogenic damage to radial nerve. The selection of a method for treating fracture shaft of the humerus depends on various factors which are related to patient and type of fracture. We decided to undertake the study of fracture shaft humerus treated with plate osteosynthesis.
Aim: To study patients with diphyseal fracture of shaft of the humerus treated with plate osteosynthesis.
Materials and Methods: This was a prospective study of 40 patients with diaphyseal fractures of humerus treated by plate osteosynthesis. All the patients were treated as indoor patients at the Department of Orthopaedics, New Civil Hospital, Surat from January, 2004 to March, 2006. The maximum period of follow-up was 2 years and the minimum period of follow-up was 5 months with average follow-up of 6 months. Patients were operated as soon as they were fit for surgical procedure under anaesthesia. An informed written consent was taken. Most of the patients were operated by posterior approach except two operated through anterolateral approach. AO type narrow 4.5mm dynamic compression plates with 4.5mm cortical screws were used. Patients were called for follow-up regularly at interval of 2-4 weeks as per need. At each visit, patients were examined for pain, tenderness, skin condition, elbow and shoulder movements. All the findings were recorded. Final results were evaluated as per criteria laid down by Hunter.
Results and discussion: In the present series, 88% had excellent to good results which were almost consistent with the series reported by Dominik Heim *et al*. One patient had superficial infection which responded to daily dressing and proper antibiotic use. In Robert and Vander series, postoperative infection rate was 5.6%. In our study, 2 patients had radial nerve palsy at the time of trauma and 1 patient had postoperative radial nerve palsy. Usually, these injuries are neuropraxia. All 3 patients had full recovery within 3-4 months.
Conclusion: Though the series is relatively small and the period of follow-up is small, however it appears that: Plate fixation appears to be a good surgical option for treatment of the diaphyseal fractures of humerus. Radial nerve palsy is usually of neuropraxia and it recovers within 4-6 months.

Keywords: Diaphyseal fracture, shaft, humerus treated, plate osteosynthesis

Introduction
Movement is life was the dictum of Lucas Championniere (1910). Hey Groves (1921) and Muller (1979) [1] have also advocated early introduction of functional activities best achieved by a stable internal fixation of fractured bone (Muller, 1979).
Different modalities of treatment are available for fracture shaft of humerus [2]. It includes various conservative methods like immobilization in a sling, Thomas arm splint, U slab, hanging cast, shoulder spica cast and surgical treatment such as intramedullary nailing [3], plate osteosynthesis [4], and external fixator.
These different methods have their own advantages and disadvantages. Conservative treatment is often associated with discomfort to patient, loss of alignment, chronic edema, joint stiffness, distraction at fracture site, atrophy of muscles, osteoporosis. Surgical treatment in the form of intramedullary fixation has rotational instability, violation of rotator cuff, stiffness of shoulder and painful motion of shoulder due to prominent nail.

Method of plate osteosynthesis is sometimes associated with infection and iatrogenic damage to radial nerve.

The selection of a particular method for treating fracture shaft of the humerus depends on various factors which are related to patient and type of fracture [2].

New Civil Hospital, Surat, is one of the biggest government hospital in the region of South Gujarat. It caters to a population of district of South Gujarat and nearby districts of Maharashtra. A good number of patients with musculoskeletal diseases are treated on a regular basis at this hospital.

We decided to undertake the study of fracture shaft humerus treated with plate osteosynthesis.

This method of plate osteosynthesis, if done with proper technique, helps to prevent routine problems associated with conservative treatment by allowing early mobilization. It allows excellent return of function, the reliable progression to union and the minimal morbidity [5].

Aim: To study patients with diphyseal fracture of shaft of the humerus treated with plate osteosynthesis.

Materials and Methods

This was a prospective study of 40 patients with diaphyseal fractures of humerus treated by plate osteosynthesis. All the patients were treated as indoor patients at the Department of Orthopaedics, New Civil Hospital, Surat from January, 2004 to March, 2006. The maximum period of follow-up was 2 years and the minimum period of follow-up was 5 months with average follow-up of 6 months.

Patients were chosen at random. A standard pattern of treatment was observed. Operations were performed by surgeons with different seniority. On presentation, exact history regarding mode of injury, time since injury was taken. General condition of patient, vitals, level of consciousness were examined. A detailed examination was carried out to detect any associated injury. Necessary resuscitative measures were taken when required. Details of previous treatment were taken before admission was obtained. A detailed local examination of the injured limb was carried out regarding tenderness, swelling, overlying skin condition, deformity and distal neurovascular status. All findings were recorded. Open fractures were graded as per Gustilo and Anderson classification.

In case of open fractures, wound was cleaned and sterile dressing was put. Unnecessary movement of the injured limb was avoided. The limb was rested in above elbow posterior plaster splint and cuff and collar sling was applied. Once the patient's condition was stable, radiographs of injured limb, shoulder with humerus with elbow both anteroposterior and lateral view were taken. All patients received tetanus prophylaxis. Other X-rays for associated injuries were taken. Routine blood examination i.e. hemoglobin, random blood sugar level, blood urea, total and differential counts, urine examination for albumin and sugar were done. Open fractures were debrided and irrigated thoroughly. Swabs taken from the wound were sent for culture and sensitivity.

Patients were operated as soon as they were fit for surgical procedure under anaesthesia. An informed written consent was taken. Most of the patients were operated by posterior approach except two operated through anterolateral approach. AO type narrow 4.5mm dynamic compression plates with 4.5mm cortical screws were used.

Described by Henry, posterior approach provides excellent access to the middle and distal third of the humerus[6].

Posterior Approach

Under anaesthesia, lateral decubitus position with injured limb up was given. The limb was prepared and draped. The posterior approach splits the triceps to expose the posterior humeral shaft in its middle two thirds.

The skin was incised along the posterior surface of the arm, following a line joining the posterior edge of the acromion with the olecrenon.

The lateral brachial cutaneous nerve should be preserved. Blunt dissection was done to develop the interval between the long and lateral heads of the triceps. The radial nerve and profundus brachii vessels were identified and protected. The medial head of the triceps was then divided, and the humeral shaft was exposed proximally and distally. Reduction was achieved under vision. After countering the plate, it was put over the posterior surface of the humerus which is the tensile surface. With the help of a drill, drill holes were made. Then tapping was done with the help of a bone tap, and cortical screws were inserted and the plate was fixed to the bone [7].

Anterolateral Approach

The anterolateral approach is most often utilized for fractures of the upper third of humeral shaft. The patient is placed supine with a light padding under the shoulder to support the scapula. The forearm is placed in a supinated position while the shoulder is abducted 60˚. The skin was cut, the superficial and deep fascia were divided, with care being taken to protect the cephalic vein which was ligated after identification. The humerus is approached between the deltoid and the pectoralis major muscles proximally and through the brachialis muscle more distally. In its most distal extent, the approach continues between the biceps brachii medially and the brachioradialis laterally. Plate osteosynthesis of the humeral shaft through this approach was facilitated by partial detachment of the brachialis muscle [7]. After exposing the humeral shaft proximally and distally to the fracture site, reduction was achieved. Later on, plate was put over anterolateral surface of the humerus.

Fractures were fixed according to AO technique of dynamic compression plating. If there were multiple fragments, humerus was reconstructed in stepwise fashion. Provisional stabilization by way of reduction clamp or K-wire may facilitate this process. Whenever possible, lag screw fixation should be included as a part of the plan. For transverse and oblique fractures, plates were put in compression mode. While in rest of the fracture types, they were put in a neutralization mode. It is essential that minimum of 6 cortices and preferably 8 cortices be obtained both above and below fracture site for adequate fixation.

Wound was closed in layers over negative suction drainage tube and above elbow plaster slab was given. The patient was given broad spectrum injectable antibiotics in appropriate dose for 3 days followed by oral antibiotics for next 3 days. First postoperative dressing was done after 48 hours. Postoperative check X-ray was taken after first dressing. After removal of drainage tube, elbow and shoulder were mobilized and arm was supported in a sling in majority of patients. In patients with comminuted fracture, weak bone and non-compliant patients, some form of external support was given in the form of functional humeral brace to arm for 4-6 weeks. Full use of injured limb was allowed after complete fracture healing.

Patients were called for follow-up regularly at interval of 2-4 weeks as per need. At each visit, patients were examined for pain, tenderness, skin condition, elbow and shoulder

movements. All the findings were recorded.
Final results were evaluated as per criteria laid down by Hunter [8].

Assessment by Surgeon (Hunter's Criteria)

			Negative points
I.	Deformity		
	1.	No deformity clinically/ radiologically	0
	2.	No deformity clinically; minimal radiological deformity	1
	3.	Marked clinical and radiological deformity	2
II.	Movements		
	(A)	Shoulder joint	
		Full movements	0
		Abduction and external rotation (Less than full, more than 60^0)	1
		Abduction and external rotation (30^0-60^0)	2
		Abduction and external rotation (30^0)	3
	(B)	Elbow joint	
		Full range to 10^0 loss	0
		10^0-45^0 loss	1
		45^0-90^0 loss	2
		>90^0loss	3
	(C)	Wrist and finger stiffness	
		Absent	0
		Present	1
III.	Radial nerve palsy		
		No palsy/ complete recovery	0
		Partial recovery/ recovering	1
		No recovery	2
IV.	Union		
		Fracture united	0
		Delayed union (12 weeks after original trauma)	1
		Non union (fracture not uniting after 24 weeks)	2

Assessment by Patients

(1)	No restriction of activity	0
(2)	Minimal restriction, not impeding daily activities	
(3)	Restriction permitting daily activities with some difficulty	1
(4)	Severe restriction preventing or impeding daily activities	
(5)	Total restriction preventing all activities	2

Grading	Negative points
Excellent	0-2
Good	3-5
Fair	6-8
Poor	>9

Observation and Results

Table 1: Shows age distribution

Age group (years)	No. of patients	Percentage
15-24	1	2.5%
25-34	13	32.5%
35-44	12	30%
45-54	7	17.5%
55-64	4	10%
65-70	3	7.5%
Total	40	

In the present series most of the patients were in the age group of 25-44 years.

Table 2: Shows comparison of mean age with other series

Series	Age range (years)	Mean age (years)
Williams & Wilkins (1998)	19-70	39
G. Tytherleigh Strong *et al* (1998)	16-94	54.6
Robert Vander Greind *et al* (1986)	40-81	36
Present series	19-70	39

Mean age of the patients in this series was comparable to other series reported by Williams & Wilkins, 1998 [9] and Robert Vander Greind *et al*, 1986 [10].

Table 3: Shows distribution of the patients according to gender

Series	Male	Female
Williams & Wilkins (1998)	68%	32%
G. Tytherleigh Strong *et al* (1998)	44.57%	55.42%
Robert Vander Greind *et al* (1986)	58.33%	41.66%
Present series	70%	30%

As evident from table 3, in the present series and in the series reported by Williams & Wilkins, 1998 [9], Robert Vander Greind *et al*, 1986 [10], more number of males sustained fracture shaft of the humerus.

Table 4: Shows distribution of the side affected

Series	Right	Left
Williams & Wilkins (1998)	44%	56%
G. Tytherleigh Strong *et al* (1998)	44.17%	55.82%
Robert Vander Greind *et al* (1986)	41.66%	58.33%
Dominik Heim *et al* (1993)	44.88%	55.11%
Present series	42.5%	67.5%

In the present series and in the series reported by Williams & Wilkins, 1998 [9], G. Tytherleigh Strong *et al*, 1998, Robert Vander Greind *et al*, 1986 [10], Dominik Heim *et al*, 1993 [11], more number of patients had fracture of left humerus.

Table 5: Shows comparison of mode of injury with other studies

Series	Fall	RTA	Assault	Other
G. Tytherleigh Strong *et al* (1998)	71.3%	17%	0%	11.7%
Robert Vandergolend *et al* (1986)	2.77%	72.22%	-	25%
Present series	45%	37.5%	17.5%	0%

In present series, the most common mode of injury was fall from height, followed by road traffic accidents and assaults.

Table 6: Depicts incidence of open/ closed injury

Series	Closed	Open
Williams & Wilkins *et al*(1998)	80%	20%
G. Tytherleigh Strong *et al* (1998)	59.83%	40.16%
Dominik Heim *et al* (1993)	92.91%	7.8%
Present series	97.5%	2.5% (type I)

In the present series, most of the fractures were closed.

Table 7: Shows comparison of different occupation of patients

Occupation	No. of patients	Percentage
Labourer	29	72.5%
Businessman	3	7.5%
Housewife	7	17.5%
Student	1	2.5%

Incidence was highest among labourers.

Table 8: Shows distribution of fracture according to level

Series	Upper third	Middle third	Lower third
Williams & Wilkins *et al* (1998)	12%	68%	20%
G. Tytherleigh Strong *et al* (1998)	25.1%	64.2%	10.7%
Dominik Heim *et al* (1993)	8.33%	63.88%	27.78%
Greind *et al*	9.65%	63.88%	27.77%
Mc Curty *et al*	39.47%	39.47%	21.05%
Present series	5%	67.5%	27.5%

In present series, middle one third of the shaft humerus was the most common level affected. In the present series, majority of the patients had fracture middle third of the shaft humerus.

Table 9: Depicts distribution of fracture according to fracture type

Series	Transverse	Spiral	Oblique	Comminuted
L. Klenerman	33.67%	39.7%	26.5%	-
Balfour	50%	50%	-	-
Robert Vander Greind *et al* (1986)	27.8%	0	27.8%	44.5%
Present series	60%	10%	20%	10%

In the present series, transverse fractures were more common.

Table 10: Shows incidence of associated injuries

Injury	Percentage
Head injury	5%
Chest trauma	2.5%
Fracture radius/ ulna	2.5%
Fracture fibula	2.5%
CLW over thigh	2.5%
Total	15%

In the present series, 15% of the patients had associated injuries.

Table 11: Shows comparison of incidence of associated injuries with other series

Series	Incidence
Dominik Heim *et al* (1993)	12%
G. Tytherleigh Strong *et al* (1998)	32%
Present series	15%

The results of the present series were comparable with the Dominik Heim *et al* study.

Table 12: Shows average time of union

Time of union	No. of patients	Percentage
16-20 weeks	30	75%
21-24 weeks	10	25%
Mean	20.5 weeks	

In most of the patients, the union time was in between 16-20 weeks.

Table 13: Shows comparison of average union time with other series

Series	Average union time
Bell, McMurty *et al* (1985)	19 weeks
H.T. Hee *et al* (2004)	21.3 weeks
Present series	20.5 weeks

Table 14: Shows comparison of range of movement after union

Series	Full ROM at elbow & shoulder
Dominik Heim *et al* (1993)	87.3%
Williams & Wilkins *et al* (1998)	96%
Present series	85%

In the present series, as in the other series, most of the patients had full range of movement at elbow and shoulder at final follow-up.

Table 15: Shows incidence of post- operative complications

Series	Infection	RNP	Non-union
Robert Vander Greind *et al* (1986)	5.6%	2.8%	2.8%
Williams & Wilkins *et al* (1998)	4%	4%	4%
Greind *et al*	2.7%	2.7%	2.7%
Mc Curty *et al*	-	2.6%	2.6%
Present series	2.5%	2.5%	-

Only 5% of the cases in the present series had post operative complications.

Table 16: Results

Series	Excellent	Good	Fair	Poor
Closed fracture (39)	18 (45%)	16 (40%)	5 (12.5%)	0
Open fracture type- I variety (1)	-	1 (2.5%)	-	-

In the present series, 87.5% patients had excellent to good results, while 12.5% had fair results. None of the patients had poor results.

Table 17: Comparison of results with other series

Series	Excellent	Good	Fair	Poor
Dominik Heim *et al* (1993)	87.3%		12.7%	-
E.S.L. Meekers *et al* (2002)	95%		2.5%	2.5%
Present series	88%		12%	-

Most of the patients had excellent to good results.

Discussion

This was a prospective study of 40 cases of diaphyseal fractures of shaft humerus treated with plate osteosynthesis. All patients were treated at Department of Orthopaedics, New Civil Hospital, Surat. Follow-up period ranged from maximum of 2 years to minimum of 5 months with average being 6 months.

Fractures of the humerus diaphysis are commonly encountered by orthopaedic surgeons accounting for approximately 3% of all fractures [7].

The average age of the patients was 39 years in the series reported by Williams & Wilkins (1998) [9] and in the present series. Our observation is consistent with that of the literature. It is evident that the fracture shaft of humerus is more common in young active people. Probably people from this age group are actively engaged in working and more likely to accidents in farming, at their working place and to road traffic accidents (Table-2).

In the series reported by Williams & Wilkins [9], Robert Vander Greind *et al.* [10] and in the present series, more

number of male patients had sustained this fracture. As more numbers of males are engaged in different jobs and working, compared to females, they are more likely to sustain this fracture (Table-3).

As evident from Table-4, in the series reported by Williams & Wilkins [9], G. Tytherleigh, Robert Vander Greind [10], Dominik Heim [11] and in the present series, more number of patients had sustained fracture of left humerus. We believe that, it is a matter of chance, which side is involved in the trauma.

Humerus shaft fracture can occur due to direct and indirect trauma [2]. Usual modes of injury are fall, road traffic accidents, assault etc. In the present series and in the series reported by G. Tytherleigh 45% and 71.3% of patients had sustained fractures due to fall respectively. Road traffic accidents were the second most common cause of this injury. We believe that with the increase in number of vehicles on the road and poor traffic disciplines, more number of patients are likely to get fracture due to road traffic accidents (Table-5).

Humerus is well covered with muscles. A high velocity injury is required to produce an open fracture in contrast to tibia which is a subcutaneous bone. In series reported by Dominik [11] and Williams & Wilkins [9], majority of fractures were closed. Our observation is similar to that of the literature.

Another classification of fracture humerus is as per fracture line. Usually transverse fractures are caused by a fall. Rotational injuries create a spiral fracture. As expected, high energy trauma causes comminuted fractures [2].

In the present series, more number of patients had transverse fractures indicating low energy trauma. In a study reported by Robert Vander Greind [10], 44.5% of patients had comminuted fracture. In his series, majority of patients had sustained fracture due to road traffic accidents indicating a high energy trauma (Table-9).

There is always a possibility of an associated injury in a patient with fracture shaft humerus, in the present series, 15% of patients had associated injury and incidence is similar with the series reported by Dominik Heim [11]. This implies that possibility of associated injury should always be kept in mind and a search should be made for diagnosis to minimize complication. Associated injury should be treated as per the merit.

Management of humerus shaft has been the subject of controversy [9].

Different modalities of treatment are available for treating fracture shaft of humerus i.e. non operative, flexible intramedullary nails, locking nail, plate osteosynthesis, external fixator, etc. Each method has its advantage and disadvantage. In the present series, all patients were treated with plate osteosynthesis.

Compression plate fixation techniques as developed and refined by Swiss AO/ASIF group have been shown to be effective in most indications for internal fixation of humeral shaft fracture [2]. Early mobilization after plate osteosynthesis prevents stiffness of joints, muscle wasting and osteoporosis (Fracture disease).

As majority of our patients were from low socioeconomic group, their postoperative compliance was doubtful. So, to be on safer side, arm was supported with some form of external support for 6-8 weeks. However, the joints were made free at the earliest depending upon fracture stability.

Humerus can be approached by either anterior or posterior approach. In the present series for fractures of middle third and distal third, posterior approach was used and for upper one third, anterior approach was used. A careful isolation, mobilization and protection of radial nerve is essential to minimize postoperative radial nerve palsy in posterior approach. In all operative stabilization of the humerus shaft fractures, it is essential that a minimum of six and preferably eight cortices be obtained both above and below the fracture site. This was practiced in the present series [7].

Normal healing of humerus fracture occurs over 8 to 10 weeks[2]. Though this was not the case in present series. In the present series, the average union time was 20.5 weeks. In the series reported by H.T. Hee [12] and Bell [5], average union time was 21.3 and 19 weeks respectively. Our observation is almost consistent with that of literature (Table- 13).

We have evaluated results as per Hunter's criteria. In the present series, 88% had excellent to good results which were almost consistent with the series reported by Dominik Heim *et al*. [11].

Complications

Postoperative infection is always a threat following any surgical procedure. In the present series, one patient had superficial infection which responded to daily dressing and proper antibiotic use. In Robert and Vander series, postoperative infection rate was 5.6%. Proper use of antibiotics, good surgical technique and proper operative room conditions are important in minimizing postoperative infection.

Radial nerve palsy accompanies fracture of the humerus shaft 6% to 15% of the time[2]. Radial nerve injury can be present at the time of trauma, or can occur postoperatively. In the present series, 2 patients had radial nerve palsy at the time of trauma and 1 patient had postoperative radial nerve palsy. Usually, these injuries are neuropraxia [2]. All 3 patients had full recovery within 3-4 months.

Exploration of radial nerve is indicated in the following situations:

1. Failure of appearance of clinical signs of recovery after a reasonable period of time has passed, which is at least 4 months [2].
2. If the fracture is open, the nerve should be explored because of the documented risk of the presence of a surgically correctable lesion [2].
3. Radial nerve palsy occurring after reduction cast given for distal third of shaft humerus fracture as there are chances of nerve getting caught between two fragments[13].

A careful isolation and gentle handling and protection of the radial nerve during surgical exposure will minimize the risk of postoperative radial nerve injury.

Plate osteosynthesis may result in up to 60% nonunion [2]. Fortunately in the present series, there was not a single case of nonunion. This is probably because most of the fractures occurred as a result of low energy trauma, more number of closed fractures, absence of a deep infection and a relatively small series.

At final follow-up, all patients except 1 (case number 15), had resumed their original work. All were satisfied subjectively. A lone patient (case number 15) had a concomitant soft tissue injury at elbow and developed stiffness. He changed his job of carpentry to light work due to stiffness of elbow.

As majority of patients were from outstation, they could not attend physiotherapy department regularly for postoperative physiotherapy. We believe that regular course of physiotherapy would have increased number of patients with excellent results.

Conclusion

Though the series is relatively small and the period of follow-up is small, however it appears that: Plate fixation appears to be a good surgical option for treatment of the diaphyseal fractures of humerus. Radial nerve palsy is usually of neuropraxia and it recovers within 4-6 months. A careful isolation, mobilization and protection of radial nerve will minimize incidence of post-operative radial nerve palsy. A good surgical technique and judicious use of antibiotics will prevent infection. Adherence to technique and principles of AO will reduce the occurrence of complications and help in achieving good results. Posterior approach is better for fixation of middle and lower third of shaft humerus fracture and anterolateral approach is better for fixation of upper third of shaft humerus fracture. A good post-operative physiotherapy is important to improve final functional results. In uncooperative, non-compliant patients, and in unstable fixation, an external support should be given to prevent fixation failure.

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