Original Article

Outcome of humeral shaft fractures treated by functional cast brace

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Abstract

Background: Functional brace application for isolated humeral shaft fracture persistently yields good results. Nonunion though uncommon involves usually the proximal third shaft fractures. Instead of polyethylene bivalve functional brace four plaster sleeves wrapped and molded with little more proximal extension expected to prevent nonunion of proximal third fractures. Periodic compressibility of the cast is likely to yield a better result. This can be applied on the 1st day of the presentation as an outpatient basis. Comprehensive objective scoring system befitting for fracture humeral shaft is a need.

Materials and Methods: Sixty six (male = 40, female = 26) unilateral humeral shaft fractures of mean age 34.4 years (range 11–75 years) involving 38 left and 28 right hands were included in this study during April 2008 to December 2012. Fractures involved proximal (*n* = 18), mid (*n* = 35) and distal (*n* = 13) of humerus. Transverse, oblique, comminuted and spiral orientations in 18, 35 and 13 patients respectively. One had segmental fracture and three had a pathological fracture with cystic bone lesion. Mechanisms of injuries as identified in this study were road traffic accidents 57.6% (*n* = 38), fall 37.9% (*n* = 25). 12.1% (*n* = 8) had radial nerve palsy 7.6% (*n* = 5) had Type I open fracture. Four plaster strips of 12 layers and 5–7.5 cm broad depending on the girth of arm were prepared. Arm was then wrapped with single layer compressed cotton. Lateral and medial strips were applied and then after molding anterior and posterior strips were applied in such a way that permits full elbow range of motion and partial abduction of the shoulder. Care was taken to prevent adherence of one strip with other except in the proximal end. Limb was then put in loose collar and cuff sling intermittently allowing active motion of the elbow ROM and pendular movement of the shoulder. Weekly tightening of the cast by fresh layers of bandage over the existing cast brace continued.

Results: The results were assessed using 100 point scoring system where union allotted 30 points and 60 points allotted for angulations (10), elbow motion (10), shoulder abduction (10), shortening (5), rotation (5), absence of infection (10), absence of nerve palsy during treatment (10). Remaining 10 points were allotted for five items with two points each. They were the absence of skin sore, absence of vascular problem, absence of reflex sympathetic dystrophy (RSD), recovery of paralyzed nerve during injury and recovery of paralyzed nerve during treatment. Results were considered excellent with 90 and above, good with 80–89, fair with 70–79 and poor below 70 point. Results at 6 months were excellent in 43.94% (*n* = 29), good in 42.42% (*n* = 28), fair in 9.1% (*n* = 6), poor in 4.55% (*n* = 3). Union took place in 98.48% (*n* = 65) with an average of 10.3 weeks (range 6–16 weeks). 87.5% (*n* = 7) paralyzed radial nerve recovered. All wounds healed. Four patients had transient skin problem. One patient with mid shaft fracture had nonunion due to the muscle interposition.

Conclusion: Modified functional cast brace is one of the options in treatment for humeral shaft fractures as it can be applied on the 1st day of the presentation in most of the situations. Simple objective scoring system was useful particularly in uneducated patients.

Key words: Cast brace, humeral shaft fracture, objective scoring system
MeSH terms: Humeral fractures, plaster casts, arm injuries

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Introduction

Shaft or diaphyseal fracture of the humerus is defined as extra articular fractures of the humerus excluding 5 cm in each ends.[1] This fracture accounts 3% of all fractures.[2] First reference on this issue is by Edwin Smith papyrus at about 3000 BC is contained in Breasted article published in 1932.[3] Conservative treatment was only treatment continued for 5000 years. In last 100 years, various operative techniques developed and successfully used to manage difficult fractures. Initial classifications described are based mainly on the location and to some extent on morphology of the fractures.[4] Subsequently AO classification combined them adequately but, while treating them,

biological environments were paid less importance.[1] The causes of diaphyseal fractures are simple fall, fall from height, sports injuries, road traffic accidents (RTAs) and direct blow.[5] It can be treated by different operative methods using open, dynamic compression or percutaneous helical plates,[2,6,7] nails[8] and external fixator.[9,10] However, all of them are with their own complications like pseudoarthrosis, superficial and deep infection, radial nerve palsy, shoulder stiffness, supraspinatus and bicepetal tendon injuries, axillary nerve palsy and implant failure, pin track infection, etc.[1,2,6,7,9,10-12] Reoperations or implant removals are also important issues.

Nonoperative treatment as the definitive method do not interfere the biological environment at the fracture site and provide more chance of union with fewer complications. As the required procedure can be performed in an outpatient department, hospitalization can be avoided. Different nonoperative procedures such as hanging cast, U cast and few other methods are successfully employed. But the technique described by Sarmiento is widely practiced all over the globe.[13] Nonunion with this method of treatment is rare; but when it occurs it involves usually the proximal third shaft humeral fractures.[14]

We hypothesized that the functional brace used by Sarmianto can be made more effective if compression of the cast over arm can be adjusted according to the loss of girth of arm during the course of treatment. More extension of the cast over the shoulder secures further stability at fracture site particularly in more proximal fractures. In the present study, modified technique of functional cast and brace was used, and the clinical results were assessed using an objective scoring system.

Materials and Methods

Sixty six consecutive patient (male = 40, female = 26) presented between January 2007 and July 2013 were included in this study. Average age of the patients 34.4 years (range 11–75 years) involving left and right arms in 38 (dominant left hand = 4) and 28 (dominant left hand = 2) patients respectively.

Cases are selected on the basis of fracture of shaft humerus 5 cm distal to the anatomical neck to 5 cm proximal to the lateral epicondyl of the humerus.[1] Closed comminuted or noncomminuted, segmental fractures with or without radial nerve palsy and open Gustillo-Anderson Grade I injuries without radial nerve palsy were included in this study.[9] Clinicoradiologically benign cystic lesions which appeared to be simple bone cyst were also included in this study. Open injury with higher grade and fractures with radial nerve palsy, poor skin condition, bilateral fractures and associated multiple fractures were excluded. Ethical clearance was obtained from a competent authority.

Fractures involved proximal shaft in 18 (male = 11, female = 7), mid shaft in 35 (male = 21, female = 14) and distal shaft in 13 (male = 8, female = 5) patients. Transverse, oblique, comminuted and spiral orientations were in 29, 23, 8 and 5 respectively. One female patient had segmental fracture. Mechanism of injuries was RTA 57.6% (n = 38), fall 37.9% (n = 25), fall from height (n = 1), direct blow (n = 1) and fall of collapsing wall on body (n = 1). Three children (4, 16 and 43) had a pathological fracture in proximal shaft which clinicoradiologically appeared to be simple bone cyst. Occupation distribution in this series are manual worker 51.5% (n = 34), house wives 27.3% (n = 18), students 19.7% (n = 13) and one home confined patients. 12.1% (n = 8) patients had radial nerve palsy; 7.6% (n = 5) patients had open fracture with punctured wound: 34.8% (n = 23) patient were smoker, 19.7% (n = 13) were diabetic, 9.1% (n = 6) were hypertensive. Of them 7.6% (n = 5) were combined diabetic and hypertensive. One patient had second trimester pregnancy. None had clinical features of acute compartment syndrome of any compartment of upper limb [Table 1].

Technique

In 28.8% (n = 19) cases with Grade I open fractures and those showing extensive soft tissue reactions U slab with or without forearm incorporation was applied. All cases with an open fracture, the wounds were debrided. Reduction was done in sitting posture without anesthesia. U slabs were extended from the root of the neck to the axilla., Well-padded molded slab was applied to prevent lateral angulations. Rotation was maintained with 30° to coronal body plane. 5 days parental antibiotic (Cefuroxim axtle) was administered to patients with open injuries. Forearm was included in a separate slab, in elbow 90° and forearm pronated, in those cases where the fractures were at more distal level. This extended slab is maintained up to 2 weeks after which cast brace in modified technique is applied (n = 19). Check X-rays were obtained at 2 and 4 weeks [Figure 1A (a)]. Overlaps up to 2 cm were ignored but angulations more than 30° is indication for remanipulation. All the limbs were kept in cuff and collar (C C) sling uninterruptedly for 10–14 days. Sling was loosened where overlap is found to be more than 2 cm in 1st week.

However, in 71.2% (n = 47) of cases functional cast brace was applied on the 1st day of the presentation.

Four plaster strips of 12 layer and 5–7.5 cm broad depending on the girth of arm were prepared [Figure 1A (b and c)]. Lateral strip length was from just distal to lateral epicondyl

Table 1: Clinical details of patients

Sex/age	Occupation	Smoker	Co-morbid conditions	Sides	Presentation (days)	Mechanism	Classification	Radial N palsy
Male/16	Student			R	6	Fall	Prox/trans/close	Nil
Female/42	HW			R	5	RTA	Mid/obl/close	P
Male/55	MW	Y	D+H	L	8	RTA	Mid/trans/close	Nil
Male/12	Student		Cystic lesion	L	8	Fall in sports	Prox/obl/close	Nil
Female/23	HW			R	5	Fall	Dis/spiral/close	Nil
Male/37	MW			L	11	RTA	Mid/trans/close	Nil
Female/22	HW			R	2	RTA	Mid/obl/close	P
Male/16	Student			L	3	Fall	Prox/trans/close	Nil
Female/52	MW		D	L	5	RTA	Prox/trans/close	Nil
Male/38	MW	Y		L	8	Fall	Mid/trans/close	Nil
Female/64	HW	Y	D	R	3	Fall	Mid/trans/close	Nil
Female/13	Student			R	4	Fall	Dis/spiral/close	P
Male/16	Student			R	6	RTA	Dis/spiral/close	Nil
Female/61	HW		D	R	3	Fall	Prox/trans/close	Nil
Male/26	MW	Y		L	7	RTA	Dis/obl/open	Nil
Male/11	Student		Cystic lesion	L	7	Fall in sports	Prox/obl/close	Nil
Female/55	HW		D	R	1	RTA	Mid/spiral/close	Nil
Female/14	Student			L	3	RTA	Mid/obl/close	P
Male/28	MW	Y		L	2	RTA	Mid/trans/close	Nil
Female/67	HW		D+H	R	6	Fall	Prox/obl/close	Nil
Male/27	MW			R	6	Fall	Prox/trans/close	Nil
Male/23	Student			L	8	RTA	Mid/obl/open	Nil
Female/32	MW			L	4	RTA	Prox/trans/close	Nil
Female/24	MW			L	4	RTA	Mid/trans/close	Nil
Male/59	HW	Y		L	3	RTA	Prox/spiral/close	Nil
Male/19	MW	Y		L	1	RTA	Mid/trans/close	Nil
Female/31	MW			R	2	Fall	Mid/comi/close	P
Male/16	Student			L	6	RTA	Dis/trans/close	Nil
Female/72	HW			R	5	RTA	Mid/trans/close	Nil
Male/17	Student			R	3	Fall	Dis/obl/close	Nil
Female/22	HW			L	10	RTA	Mid/obl/close	Nil
Male/45	MW	Y		L	3	RTA	Prox/trans/close	Nil
Female/75	HW			L	8	Fall	Mid/comi/close	Nil
Male/21	MW	Y		L	4	RTA	Prox/obl/close	Nil
Female/65	HW		D+H	L	5	RTA	Mid/obl/close	Nil
Male/20	MW	Y		R	6	Fall	Prox/trans/close	Nil
Male/49	MW	Y	D	L	8	Fall	Mid/trans/close	Nil
Female/29	HW			R	1	RTA	Mid/trans/close	Nil
Male/25	MW	Y		L	7	RTA	Mid/trans/close	P
Male/42	MW	Y		R	2	RTA	Mid/obl/close	Nil
Female/26	HW			R	4	Fall	Mid/trans/close	Nil
Male/50	MW		H	R	7	RTA	Mid/obl/close	Nil
Female/12	Student		Cystic lesion	L	4	Fall in sports	Dis/trans/close	Nil
Male/31	MW	Y		L	5	RTA	Mid/comi/close	Nil
Male/70	Home confined		D+H	R	3	Fall	Mid/trans/close	P
Male/14	Student			L	3	RTA	Mid/trans/close	Nil
Male/30	MW			L	9	Fall from height	Prox/obl/open	Nil
Female/62	HW		D+H	L	5	Fall	Mid/comi/close	Nil
Male/38	MW	Y		R	3	RTA	Mid/trans/close	Nil
Male/39	MW	Y		L	4	Fall	Dis/obl/close	Nil
Male/15	Student			L	19	Fall from height	Prox/obl/close	Nil
Female/38	HW			R	1	Fall	Dis/obl/close	P

Contd...

Table 1: Contd...

Sex/age	Occupation	Smoker	Co-morbid conditions	Sides	Presentation (days)	Mechanism	Classification	Radial N palsy
Female/52	HW			R	1	Fall	Prox/comi/close	Nil
Male/40	MW	Y	D	R	3	RTA	Mid/comi/close	Nil
Male/31	MW	Y		L	11	RTA	Mid/trans/close	Nil
Male/30	MW			R	23	Direct blow	Mid/obl/close	Nil
Male/41	MW			L	17	RTA	Mid/obl/open	Nil
Male/30	MW	Y		L	1	RTA	Dis/comi/close	Nil
Male/45	MW	Y	D	R	5	RTA	Mid/trans/close	Nil
Male/45	MW	Y		L	3	RTA	Mid/trans/close	Nil
Female/18	House made			L	5	Wall collapse	Mid/trans/close	Nil
Female/28	HW			R	16	Fall	Dis/segment/close	Nil
Male/34	MW			R	2	RTA	Dis/comi/close	Nil
Male/45	MW	Y	D	L	4	Fall	Dis/obl/open	Nil
Male/28	MW	Y		L	2	RTA	Prox/obl/close	Nil
Female/29	HW			L	1	RTA	Mid/obl/close	Nil

N=Nerve, MW=Manual worker, HW=House worker, RTA=Road traffic accident, Prox=Proxymal, Mid=Middle, Dis=Distal, Trans=Transverse, Obl=Oblique, Comi=Comminuted, D=Diabetic, H=Hypertensive, L=Left, R=Right, Y=Yes, P=Palsy

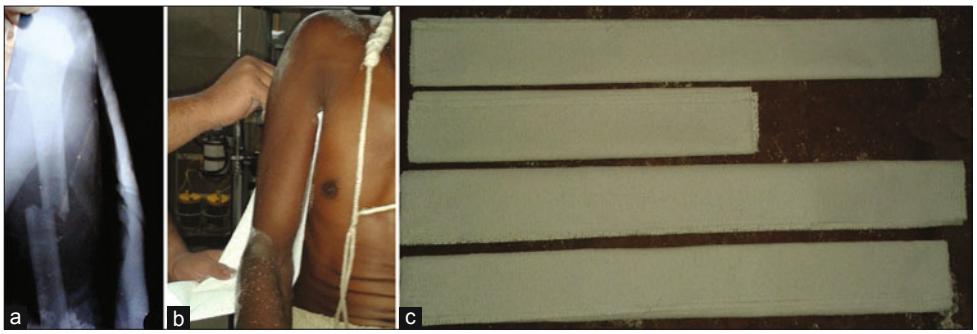

Figure 1A: (a) X-ray of left arm with shoulder joint showing fracture of left humeral shaft (b) Clinical photograph showing measurements of plaster of paris cast strip (medial) on the sound side (c) Longitudinal triple folding of 15 cm plaster bandage for lateral, medial, posterior and anterior aspects

Figure 1B: Clinical photographs showing (a) lateral and medial strips are applied (b) molding to correct residual deformities (c) anterior and posterior strips are applied (d) final picture

to just proximal to the acromion; medial strip extends from just distal to medial epicondyl to the axillary folds; anterior strip extends from 2 cm proximal to anterior elbow crease to acromioclavicular joint and posterior one from just proximal to the tip of the olecranon in extended elbow to the acromioclavicular joint. This allows them to overlap each other at the proximal part. Arm is then wrapped with a single layer compressed cotton which extends around the chest wall in the fashion of spica. First, medial and lateral strips are placed after soaking in water and genty

squeezing them and cotton bandage was wrapped over it [Figure 1B (a and b)]. As the casts set in it was molded to prevent lateral angulations in sitting position. Anterior and posterior slabs were then placed and tightened and molded to prevent posterior angulations [Figure 1B (c and d)]. Residual angulations usually lateral and posterior if observed in check X-ray could be corrected at that stage. Care was taken to prevent adherence of one strip with other except in the proximal end. Limb was then put in loose collar and cuff sling intermittently and allowed active motion of the elbow and pendular movement of the shoulder. Arm sling intermittently was reserved for cases where there is any tendency of distraction at fracture site seen in check X-ray. The bandage and cotton which were applied over the chest wall were discarded after the cast sets in or may be retained for few weeks. In obese patients, this was preferred to maintain for 4–6 weeks to prevent slipping down. Patients were directed to attend the clinic weekly for tightening of the cast by fresh layers of bandage over the existing. In four occasions cast need to split between anterior and medial strips to remove it for providing care of the skin problems and reapplied in position for 4–5 days. After that it was reapplied freshly in the same manner. Check X-rays were taken 1 week and 5 weeks after cast brace [Figure 2A (a)]. With radiological evidence of union, cast brace was removed and rehabilitation program, consisting of active exercises of the hand, wrist, elbow and shoulder along with shoulder mobilizing exercises at least for ½ h and 2 times daily, were started. They were instructed to use CC sling intermittently for another 2 weeks for protection and after which activities were permitted as per tolerance. Subsequent followups were after 1 month, 3 months and 6 months and then yearly [Figure 2A (b and c)].

Assessment had been made at each followup visits on the basis of an objecting scoring system [Table 2].

Features of this new scoring system contain 100 points distributed on nine criteria. Criteria are union time (30 points), angulations at union site (10 points), residual rotation at union site (5 points), shortening of the humerus (5 points), elbow motion arc (10 points), shoulder abduction motion arc (10 points), absence of infection during the course of treatment (10), absence of nerve paralysis during the course of treatment (10 points) and others (10 points). Others include five criteria. They are the absence of skin sore or irritation (2 points), recovery of paralyzed nerve during

Figure 2A: (a) X-ray of the arm with shoulder joint showing comminuted fracture 1 month after cast brace application (b) Same patient after 4 months showing good consolidation in anteroposterior view and (c) in lateral view

Figure 2B: Clinical photographs at 3 months followup when cast was removed showing (a) functional results of elbows flexion (b) internal rotation of shoulders (c) abduction of shoulders

Table 2: Objective scoring system for assessment of results

Criteria	Points (total=100)	
Union time (weeks), total points=30	Upto 08	30
	09-10	25
	11-12	20
	13-14	15
	15-16	10
	17 and above	05
Angulations (°), total points=10	00-05	10
	06-10	08
	11-15	06
	16-20	04
	21-25	02
Rotations (°), total points=05	00-05	05
	05-10	04
	11-15	03
	16-20	02
	21 and above	00
Shortening (cm), total points=05	Upto 0.5	05
	0.6-01	04
	1.0-1.5	03
	1.6-2.0	02
	2.1-2.5	01
Elbow motion arc (°), total points=10	More than 130	10
	121-130	08
	111-120	06
	101-110	04
	91-100	02
Shoulder abduction arc (°), total=10	171-180	10
	161-170	08
	151-160	06
	141-150	04
	131-140	02
Absence of infection developed during treatment	10	
Absence of nerve paralysis during treatment	10	
Others, total points=10	Recovery of paralyzed nerve during injury	02
	Absence of skin sore/irritation	02
	Absence of vascular compromisation during treatment	02
	Absence of RSD	02
	Recovery nerve paralysis during treatment	02

Resulting score			
Excellent	Good	Fair	Poor
90 and above	80 to 89	70 to 79	69 and below

RSD=Reflex sympathetic dystrophy

injury (2 points), absence of vascular compromisation during treatment (2 points), absence of RSD (2 points) and recovery of nerve paralysis developed during treatment (2 points) [Table 2]. The values remained almost similar in all visits except the arc of abduction of the shoulder.

Movements of elbow and shoulder joints were measured. Arm lengths were compared with the sound side. Combined shoulder internal and external rotation ranges were found equal on both side and that allowed to estimate the rotations at the fracture sites. There is no incidence of any nerve injury or infection developing during the course of treatment.

Results

Mean followup period was 41.1 months (range 15–60 months). Fracture in one patient (1.5%) did not unite (case number: 44). At the removal of the cast brace, average union time of 65 patients was 10.3 weeks (range 6–16 weeks). Average varus angulations were 9.2° (range 0–30°). Average rotation was 3.1° (range 0–15°). Average shortening was 0.51 cm (range 0–2 cm). Available painless elbow and shoulder abduction motion was 118.3° (range 70–145°) and 155.2° (range 135–180°) respectively [Figure 2B (a-c)]. In subsequent followup at 6 weeks shoulder abduction was improved to 166.5° (range 140–180°). However, other findings were similar as it were during removal of the cast. In subsequent followups, these features remained unchanged. All three children with pathological fractures united without persistence of cystic bone lesions. Wound healed in all five open fractures. 87.5% (n = 7) radial nerve injuries during fracture were recovered within 6–8 weeks. Four patient developed skin irritation and sore which were healed with change of cast and dressings. None develop nerve palsy, deep infection, vascular compromisation or RSD during treatment or thereafter [Table 3].

As per objective scoring system described here the final results at 6 months were excellent in 43.9% (n = 29), good in 42.4% (n = 28), fair in 9.1% (n = 6), poor in 4.6% (n = 3). Thus combining excellent and good result were found in 86.4% (n = 57). However, union took place in 98.5% (n = 65).

Discussion

Cast brace recommended by Sarmiento *et al.* obtained promising result, while treating humeral shaft fracture.[13] Many authors followed the same principle to get uniformly good results.[14-20] This principle is based on Pascal's Law of physics. Modified technique is also based on the same principle. Few differences in technique are there. It is made up of plaster strips which allow molding to correct angulations and the vertical inter strip free space permits required compression resulted from subsidence of edema or wasting of arm muscles. In most occasions, it is applied on the day one except some special situation like open injury and skin problem. Though most authors do recommend using functional brace after an interval of 7 days–3 weeks when some other procedures are done.[14-16]

Table 3: Results at 6 months followup

Union time (weeks)	Angulations (degree)	Rotation (degree)	Shortening (cm)	Elbow motion (degree)	Shoulder abduction (degree)	Complications developed during Rx	State of all complications	Score	End point
8	10	0	0.5	0-135	0-170			96	Excellent
11	5	5	0	0-130	0-175		N recovered	90	Excellent
10	15	0	1	5-130	0-160			84	Good
7	10	10	0.5	0-135	0-165		Cyst healed	93	Excellent
10	10	10	1	0-130	0-170			87	Good
12	0	10	1.5	5-130	0-170			83	Good
10	5	0	0	0-145	0-165		N recovered	93	Excellent
9	15	5	0.5	5-125	0-170			90	Excellent
12	10	5	1	0-140	0-165	Skin sore	Healed	83	Good
10	15	0	1.5	5-125	0-175			85	Good
13	5	0	0	0-135	0-180			85	Good
9	10	0	1	0-125	0-175		N recovered	90	Excellent
8	10	10	0.5	5-125	0-160			89	Good
13	15	0	1.5	5-125	0-165			73	Fair
10	15	10	1	5-135	0-170		Would healed	85	Good
6	5	0	0	0-135	0-180		Cyst healed	100	Excellent
10	5	10	0	0-130	0-175		N recovered	92	Excellent
9	5	0	0	0-135	0-170			93	Excellent
12	10	0	0.5	5-130	0-165			84	Good
14	15	5	1	10-125	0-160			72	Fair
11	10	0	0.5	5-140	0-175			88	Good
9	5	0	0	0-140	0-180		Wound healed	95	Excellent
10	10	0	0.5	5-120	0-165			87	Good
9	5	0	0	0-130	0-180			93	Excellent
12	15	10	2	5-120	0-155			74	Fair
12	10	5	0	0-125	0-170			84	Good
10	0	0	0	0-140	0-180		N recovered	95	Excellent
9	5	0	0	0-140	0-180			95	Excellent
12	10	0	0	0-135	0-170	Skin sores	Healed	86	Good
9	10	0	0	0-135	0-180			93	Excellent
10	10	5	0.5	0-140	0-175			93	Excellent
10	5	5	0.5	5-130	0-175			93	Excellent
14	25	15	2	20-110	0-150			56	Poor
9	5	0	0	0-130	0-180			93	Excellent
12	15	0	1	10-120	0-170			77	Fair
10	5	0	1	5-140	0-170			92	Excellent
11	5	5	0	0-130	0-180			88	Good
9	10	5	0	0-140	0-180			93	Excellent
10	10	0	0.5	5-140	0-165		N recovered	81	Excellent
10	5	0	0	0-135	0-170			93	Excellent
13	5	0	0	0-140	0-165			83	Good
10	10	5	0.5	5-135	0-170			89	Good
8	0	0	0	0-140	0-180		Cyst healed	100	Excellent
No union									Poor
16	25	10	2	15-120	0-1505	Skin sores	N recovered/ sore healed	54	Poor
9	5	0	0	0-140	0-180			95	Excellent
12	0	0	0	10-135	0-170		Wound healed	86	Good
12	15	0	2	10-115	0-155			73	Fair
10	10	0	1	5-125	0-150			82	Good
13	5	0	0	0-140	0-175	Skin sores	Healed	83	Good
10	0	0	0	0-145	0-175			95	Excellent
10	5	10	0	15-130	0-170		N unrecovered	86	Good
10	5	0	0	10-125	0-170			89	Good

Contd...

Table 3: Contd...

Union time (weeks)	Angulations (degree)	Rotation (degree)	Shortening (cm)	Elbow motion (degree)	Shoulder abduction (degree)	Complications developed during Rx	State of all complications	Score	End point
9	5	0	0	0-140	0-165			93	Excellent
12	5	5	0	0-130	0-170			86	Good
12	30	5	2	0-140	0-160			71	Fair
10	5	5	0	20-135	0-155		Wound healed	85	Good
11	5	0	0	0-125	0-175			88	Good
12	0	0	0	0-145	0-180			90	Excellent
12	10	10	0.5	0-125	0-170			83	Good
10	0	0	0	0-135	0-180			95	Excellent
10	15	10	1	0-125	0-165			85	Good
10	10	0	0.5	0-135	0-180			93	Excellent
9	5	5	0	5-135	0-175		Wound healed	93	Excellent
10	10	0	0.5	0-120	0-170			87	Good
10	15	0	1.5	0-130	0-160			83	Good

Rx=Treatment

When fracture is at the proximal shaft, the anterior, the lateral and the posterior strips are extended 2 cm proximal to acromion. This causes more rigid immobilization of the fracture site thus allow pain relief in the early stage. The shoulder abduction can be done up to 60°.[5] Two important problems are observed in this study. Seven patients had blebs, but three of them complained of it and we had to change the cast for skin care. In other four occasions, healed blebs were observed during final removal of the cast. The other problem is during final removal of the cast the average shoulder abduction arc was 155.2° which however improved to 166.5 within next 2 weeks during rehabilitation exercises. Prefabricated brace is more comfortable, skin care is easy, can be used for very prolonged period and shoulder rehabilitation is obtained even before the fracture unites. While treating with prefabricated functional brace, in many occasions it became dangerous to the noncomplied patients where we found they do not use the brace not only in terms of hours but sometimes in days. This is because of the easy removability. Thus provoke delayed or even nonunion. This picture is observed in unpublished comparative study conducted by us in Indian study population which is not included in this study. However, Bhalla *et al*. and Mavani *et al*. from India did not mention this problem in their articles.[18,19] Cost of treatment is another issue. Other conservative procedures like U cast or hanging cast also yield good rate of union. However, the recovery of joint functions is a persistent problem. Distraction at fracture occasionally provoke delayed or nonunion. In the present series, we found one such incidence and all patients participated in light activities in and around 4th week.

Papasoulis *et al*. in their review article analyzed outcome of 16 case series of functional cast brace treatment of humeral shaft fracture and two comparative studies.[14] They concluded that average healing time is 10.7 weeks,

Figure 3: X-ray left arm with elbow joint showing fracture nonunion

the union rate 94.5%, proximal shaft fractures have higher nonunion rate. Full shoulder and elbow motion was obtained in 80% and 85% respectively. Subjective parameters were also not satisfactory. In the present study union time is 10.3 weeks, union rate is 98.5%, and obtained full elbow motion in 80% and full shoulder motioned in 82%. One fracture which did not unite is not of the proximal third of the shaft. During the operation, it was found that soft tissue interposition was the reason for nonunion [Figure 3].

Denard *et al*. conducted retrospective comparative study of 213 adult humeral shaft fractures between functional brace or operative using compression plate and noted outcomes.[20] Incidence of nonunion in nonoperative versus operative was 20.6% versus 8.7%, malunion 12.7% versus 1.3%, wound infection rate 3.2% versus 4.7%, and radial nerve palsy after treatment 9.5% versus 2.7%. They favored operative treatment with a compression plate. Present study, though is not comparative one, has a disagreement

with most of their observations on nonoperative group. However, Tan *et al*. claimed improved results with helical plates and minimal invasive techniques. However, it is not yet, time tested, and results in the present series show adequate patients' satisfaction.[7]

Shao *et al*. after reviewing 21 scientific articles which include 4517 humeral shaft fractures, found an overall prevalence of radial nerve palsy of 12%. [21] It was most frequent with fractures of the middle and distal third humeral shaft and were more common with transverse and spiral fractures. Spontaneous, recovery occurred in 88%. Complete transection of the radial nerve usually occurs with open fractures of the humerus and requires nerve repair or grafting. Those with a closed fracture recover without treatment. We have a similar observation in the present study, and none developed radial or any other nerve palsy during the course of management. Various scoring systems are available in the literature for posttreatment assessment of upper limb injuries like Disabilities of the Arm, Shoulder and Hand (DASH) Score,[22] American Shoulder and Elbow Surgeons (ASES) Self-Report Form, the University of Pennsylvania Shoulder Score (U-Penn), Constant-Murley Shoulder Score (CMS), systems.[23-25] DASH and ASES. They are subjective, lengthy and difficult to understand particularly by illiterate or semi-illiterate patients. Bias factors are likely to be active. U-Penn has two different formats, subjective and objective. CMS is a combination of subjective and objective criteria. Moreover both of them are basically for shoulder assessment. Mackee considered <3 cm of shortening, angulation of <20°, and rotation of <30° as guidelines for acceptable reduction.[26] However, comprehensive, systematic, simple objective criteria for analysis of results are necessary to assess the endpoint results.

Modified functional (cast) brace can be one of the options in treatment of humeral shaft fractures as it allows its application on the 1st day of the presentation in most of the situations. Simple objective scoring system is useful even in illiterate patients. It is free of patients' subjective interpretational variations.

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