TREATMENT OF CLOSED HUMERUS DIAPHYSEAL FRACTURES USING A FUNCTIONAL BRACE

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ABSTRACT

Objective: To determine the functional outcome of closed fracture shaft of humerus treated with functional brace.
Study Design: Cross-sectional analytical study.
Place and Duration of Study: Orthopedic Surgery department, Combined Military Hospital Rawalpindi, from Jun 2018 to Nov 2018.
Methodology: A total of 45 patients of both genders having isolated closed humeral diaphyseal fracture ≤2 weeks old were included in the study. Patients were initially managed with the application of plaster of paris splint. After 7 days the splint was substituted by a functional brace and all patients were followed up on regular basis at 1st, 2nd, 4th, 8th, 12th and finally at 16th weeks.
Results: The mean age of patients was 32.8 ± 7.4 years with a range of 21-47 years. Among the total of 45 patients, 31 patients (68.9%) showed very good results, 10 patients (22.2%) showed good result, 3 patients (6.7%) showed fair result while poor result with non-union was present in 1 patient (2.2%). Union was achieved in 97.8% patients.
Conclusion: Functional brace was found an effective treatment modality in the management of close diaphyseal fractures of humerus.

Keywords: Functional brace, Humeral diaphyseal fractures, Shaft of humerus.

INTRODUCTION

The earliest record of humeral shaft fractures in literature dates back to 1600 BC in the Edwin Smith papyrus[1]. They account for 3-5% of all fractures constituting about 70,000 cases per year in North America[2,3]. Fractures of humeral shaft are more common in the males than females and follow a bi-modal distribution pattern with one peak incidence occurring among young adults (mostly male) in the 3rd decade of life and the second peak arising in old female patients between the ages of 60-70 years[4]. Road traffic accidents, injury resulting from a fall from height, inadvertent falls, assault, crush injury and pathological fractures are some of the main causes of fractures of humeral shaft[5].

Conservative non-operative management of humeral shaft fractures is a time old technique that is still applicable these days with a few modifications. Most of the humeral shaft fractures are managed conservatively with good results reported in about 90% of the cases. The conservative options available include hanging arm cast, abduction humeral splint, shoulder spica cast, Velpeau dressing, Coaptation splints or U-slabs, transolecranon traction, Mayoclinic bandage and functional brace[6].

The indications of operative interventions in cases of humeral shaft fractures include polytrauma patients, patients presenting with comminuted or open fractures with significant soft tissue injuries, bilateral humeral fractures, fractures with failure of conservative methods, pathological fractures, fractures associated with concomitant elbow, shoulder or forearm fracture and fractures associated with neurovascular injuries. Various operative options available include external fixators, dynamic compression

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plates, intramedullary nails, Kuntscher nails and cerclage wires[7].

Functional brace (figure) was first used by Augusto Sarmiento in the year 1977. It consists of a thermoplast splint that is moldable with the help *p*f Velcro straps which are tightened as the swelling subsides after a week of onset of injury to allow for continued compression on the fracture site as well as movement at both shoulder and elbow joints. Functional brace has become the gold standard treatment option for closed fractures of humeral shaft. The comfort of application, easy adjustability, allowance of elbow and shoulder motion, reduced hospital stay and decreased cost with good functional outcomes makes functional brace treatment modality of choice in most humeral diaphyseal fractures[8-10].

The rationale of this study was that there was a paucity of data regarding the conservative management of closed fractures of shaft of the humerus with the help of a functional brace in the local literature. The findings of this study will be helpful in the establishment of local evidence-based practices in the management of fractures of humeral shaft which will help to decrease the duration of hospital stay of the patients thus diminishing the demands for resources and recommending a more efficient approach to treating surgeons.

METHODOLOGY

This cross sectional analytical study was carried out at Combined Military Hospital, Rawalpindi after approval from ethical review committee. The duration of study was 6 months from 1st January 2018 to 30th November 2018. A written informed consent was taken from all patients included in the study. The sample size was calculated by the WHO sample size calculator with: (a) Confidence level=95%, (b) Absolute precision required=0.05, (c) Anticipated population proportion=97%[11], (d) Sample size= 45 patients. The sampling method implemented was non-probability consecutive sampling. The inclusion criteria was patients of both genders presenting with closed fracture of shaft of humerus diagnosed on radiographs (≤2 weeks old) with ages between 20-50 years. Exclusion criteria set for the study included polytrauma patients, open fracture, fractures with neuro-vascular injuries, comminuted fractures, pathological fractures and fractures older than 2 weeks duration.

Resolution of the edema, initial fracture stability and pain control was provided by immediate immobilization of the injured extremity via U-slab and thus the nonoperative management plan was adopted. The functional brace was applied after 1 week of settlement of soft tissue swelling. To ensure the ease of position of the forearm, a polysling was applied with examination of the distal neuro vascular status soon after the application of the functional brace. The patients were discharged from the ward usually within 24 hours with the advice regarding care of the splint and regular follow up.

All patients were followed up on weekly basis with fresh radiographs for the first two weeks, then at 4th, 8th, 12th and finally at the16th week respectively. Throughout the follow up visits, adjustment in the application of brace and new splinting was done if required. Functional outcomes in terms of pain and range of motion was estimated using the Stewart and Hundley's criteria and was labeled as Good and Bad (table-I). If there was a painful movement at the fracture site along with no visible callus on the x-ray, the case was labelled as a case of delayed union or non-uniting fracture and was operated by ORIF. Data was collected on a pre-designed proforma by the primary observer. Data was analyzed by using SPSS version 23. Mean ± SD was calculated for quantitative variables. Frequencies and percentages were computed for quantitative variables. Chi square test/Fischer exact test were applied taking $p \leq 0.05$ as significant.

Patients with very good and good functional outcome, according to Stewart and Hundley criteria, were labelled as having good final outcome and those having fair and poor

functional outcome were labelled as having bad final outcome.

RESULTS

The mean age of patients included in the study was 32.8 ± 7.4 years with a range of 21-50 years. Among total of 45 patients, 31 patients (68.9%) showed very good results, 10 patients (22.2%) showed good result, 3 patients (6.7%) showed fair result while poor result with non-union was obtained in 1 patient (2.2%). Twenty nine patients (64.4%) were males and 16 patients (35.6%) were females. The most common mechanism of injury was road traffic accident in 22 patients (48.9%), followed by inadvertent falls in 16 patients (35.6%), history of fall from height and fight in 3 patients each (6.7%) and 1 patient (2.2%) was brought with sports injury. The most common age group was 21-35 years (51.1% patients).

The right humerus was affected in 19 patients (42.2%) whereas 26 patients (57.8%) presented with fracture of left humerus. The proximal third of the humeral shaft was fractured in 16 patients (35.6%), middle third in 22 patients (48.9%) and distal third in 7 patients (15.6%) respectively. The configuration of fractures according to type is shown in (table-II). Immobilization and application of splint was kept for 8-12 weeks at an average and union was achieved in 10 weeks in most cases. After healing, the varus-valgus and postero-anterior angulations were measured with the help of a goniometer. Fewer than 10° angulation or good radiographic alignment was observed in patients with very good results. Only 1 patient (2.2%) with transverse fracture of middle 3rd of humeral shaft developed non-union with movement at the fracture site even after 16 weeks and complained of continuous pain.

Concerning movement at the elbow and the shoulder joints, there was almost full range of movement at the elbow joint in all the cases; nonetheless at shoulder joint, abduction was limited less than 20° in one patient (2.2%) and 3 patients (6.7%) had about 30° of restriction. Additional movements of shoulder were within

Table-I: Functional Outcome Criteria.

Result	Pain	Limitation of Elbow or Shoulder Mobility
Very Good	No pain	Full range of motion of both elbow and shoulder
Good	Occasional pain	<20°of limitation of elbow or shoulder
Fair	Activity related pain	20°-40° of limitation of elbow or shoulder
Poor	Constant pain	>40° of limitation of elbow or shoulder

Table-III: Association of sociodemographic variables with final outcome.

Variables	No. of Patients (n)	Groups	Outcome		*p*-value
			Good (n=41)	Bad (n=4)	
Age (years)	23	21-35	22 (95.7%)	1 (4.3%)	0.346
	22	36-50	19 (86.4%)	3 (13.6%)	
Gender	29	Male	26 (89.6%)	3 (10.3%)	1.000
	16	Female	15 (93.8%)	1 (6.2%)	
Side of fracture	26	Left	22 (84.6%)	4 (15.4%)	0.13
	19	Right	19 (100%)	-	
Site of fracture	16	Proximal third	15 (93.8%)	1 (6.2%)	0.135
	22	Middle third	21 (95.5%)	1 (4.5%)	
	7	Distal third	5 (71.4%)	2 (28.6%)	
Mechanism of Injury	22	RTA	19 (86.4%)	3 (13.6%)	0.311
	16	Inadvertent falls	16 (100%)	-	
	3	Fall from height	3 (100%)	-	
	3	Assault	2 (66.7%)	1 (33.3%)	
	1	Sports Injury	1 (100%)	0 (0%)	

normal range. Shortening of about 1.5cm was seen in 4 patients (8.9%) treated with functional brace. All patients had short slanting fractures of the humeral shaft while complete length was obtained in all the remaining cases. Only 1 patient (2.2%) developed skin maceration associated to the irritation of the skin by the splint. For these macerations, skin care and dermatological agents were used without stopping the use of the splint.

The Association of socio demographic variables to outcome has been shown in tables II.

Thus, our study revealed that there was no statistically significant difference in outcomes in terms of age, gender, side of fracture, site of fracture and mechanism of injury after conservative management of closed humeral diaphyseal fractures with a functional brace.

DISCUSSION

Conservative non-operative treatment of humeral diaphyseal fractures with the help of functional brace was found to be an effective treatment modality in our study. The working of the functional brace follows the principles of active muscle contraction accompanied by the beneficial effect of gravity and the hydraulic effect of the brace[11-14]. Prompt application of functional brace with early initiation of exercises of the elbow and shoulder joints with controlled motion at the fracture site promotes early osteogenesis and provides enhanced biomechanical stability[15].

The mean age of patients included in the study was below forty (32.8 ± 7.4) years. Similarly Khan *et al*[9] reported a mean age of below forty (34.6 ± 10.3) years in their study. Shah *et al*[16] reported a mean age of below fifty (43) years in another study from Pakistan while the mean age was found to be higher in Europe with a study by Bergdahl *et al* reporting a mean age of above fifty (66.8) years[5]. In our study, there was a male preponderance of more than half (64.4%). Shah *et al* reported the frequency of male patients to be more than half (73.3%)[16]. On the contrary, Bergdahl *et al* reported a higher frequency of female patients more than half (71%) of cases in their study[5].

The left humerus was more commonly fractured as compared to right humerus withmore than half (57.8%) patients presenting with fracture of left side. Similarly Bergdahl *et al* reported left sided fracture in more than half (54%) patients[5]. The most common mechanism of injury was road traffic accident in our study followed by inadvertent falls. Ekholm *et al*[17] in study Sweden reported that the most common mechanism of simple fall in more than half (68.0%and 56.5%) of the patients respectively while traffic accidents only comprised less than one fourth (5.0% and 6.1%) of the cases in the two studies respectively.

In our study, the middle third of humerus was the most common site of fracture followed by proximal third and the least common site was distal thirdof humerus shaft respectively. While Bergdahl *et al* reported the involvement of proximal third of humerus as the most common site in more than half (78.7%)of the cases followed by middle third in less than one fourth (13.0%)of the cases and distal third in less than one fourth (8.3%) of the cases respectively[5]. Another study by Kapil Mani *et al*[14] from India also reported that fractures of middle third as the most common site in more than half (63.9%) of the patients followed by less than one half (22.2%) of patients with fractures of distal third of humeral shaft and less than one fourth (13.9%) patients with fractures of proximal third of humerusrespectively.

Union was achieved in more than two third (97.8%) of the patients in our study. The results of our study are comparable to the union rates of 94%, 97.2%, 98.5% and 92% in studies by Pidhorz *et al*[8], Mani *et al*[14], Pal *et al*[18] and Crespo *et al*[19] respectively.

However, there are some studies reporting a high rate of non-union or delayed union in patients undergoing conservative management of humeral fractures. A study by Harkin *et al*[20] from Australia reported a union, delayed union and

malunion rates of 54%, 13% and 33% patients respectively. Ali *et al*[21] from UK also reported a high rate of non-union of more than 17% with conservative approach. The study reported a high rate of non-union for fractures of proximal-third in 24% patients as compared to 12% patients with middle-third fractures and 15% patients with fractures of distal third of humerus respectively. Neuhaus *et al*[22] and Westrick *et al*[23] reported a union rate of 80% and 76.8% respectively with conservative approach in their study.

Guidelines for acceptable reduction include less than 3 cm of shortening, anterior bowing of less than 20 degrees, malrotation of less than 15 degrees and varus angulation of 30 degrees[3]. Our study achieved very good and good functional outcomes in 91.1% patients which was comparable to other international studies. The limitations of our study are that the sample size was small and we only evaluated the patient outcomes for up to 16 weeks duration. Therefore further studies are recommended on the conservative management of humeral fractures using bigger sample size and for studying the long term complications and functional outcomes.

CONCLUSION

Most closed humeral shaft fractures can be adequately treated with the help of a functional brace which is an easy, cost effective and definitive conservative treatment modality. As this mode of treatment reduces the hospital stay of patients, it also decreases the burden on hospital resources in a significant manner.

CONFLICT OF INTEREST

This study has no conflict of interest to be declared by any author.

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