Original Research Article

Functional cast bracing in closed fractures of shaft of humerus

Shekhareswar De

Assistant Professor, Department of Orthopedics, Shri Ramkrishna Institute of Medical Sciences and Sanaka Hospitals (SRIMS & SH), Malandighi, Kanksha, Durgapur, West Bengal, India

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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. We evaluated clinical, radiographic, and functional results of patients treated with functional bracing for humeral shaft fractures. **Materials and Methods**: This clinical study was done at a tertiary care teaching hospital, Durgapur, West Bengal. Approval from the Institutional ethics committee was obtained and written informed consent from the patient was taken. Sixteen cases of unilateral, closed humeral shaft fractures involving ten right arm and six left arm cases were included in this study, during April 2018 to March 2019. Only simple, closed diaphysial fractures were selected. Initially, fractures were stabilized by hanging cast for 7 to 10 days. Analgesic & anti inflammatory drugs (NSAIDS) were advised. Patients were called on 10th days for application of cast brace. Patient was made to sit on a stool. Hanging cast was removed. A thin layer of cotton padding was applied around his arm extending from shoulder to elbow. Now plaster cast was applied extending from just below the acromion and 2 cm. below the axilla to 1.5 cm above the medial epicondyle and laterally above lateral epicondyle. Gentle traction was applied and minor correction of alignment was done. Plaster cast was snugly applied so that it was neither tight nor loose and carefully moulded to match the contour of the limb. Cuff and collar sling was given with elbow at 90®. Patient was tanght to do active exercise of shoulder, elbow and wrist. Cases were followed up at 6, 8, & 10 weeks. Each patient was thoroughly examined and findings noted. Clinical union was concluded as no pain and motion at fracture site coupled with radiological evidence of callus formation at fracture site. **Results:** Total no. of cases was 16. Majority of the cases in the age group of 21-40 yrs (53.2%) followed by 41-60 yrs [29.3%]. About 62.5% cases right sides in comparison to 37.5% were left sided humeral shaft fractures. Cases of humeral shaft fractures were more common in males (75%) in comparison to females (25%). About 62.5% cases middle third involvement in comparison to 25% were lower third humeral shaft fractures. About 37.5% cases were oblique fractures followed by 31.3% transverse and 18.7% spiral. About 62.5% cases were due to road traffic accidents [RTA] followed by 25.5% fall and 12% direct violence. About 75% cases were time of union followed noted 8-10 weeks by 25% cases time of union noted ≥12 weeks. Excellent means firm bony union without deformity and no limitation of motion and noted in 31.2% cases. Good means firm bony union, no functional impairment for ordinary purpose angulation not more than 10® and noted in 37.5% cases. Fair means firm bony union with occasional mild pain, limitation of motion in adjacent joint of more than 20% and angulation of more than 10® and recorded in 18.7% cases. Poor means persistent pain, limitation of motion in adjacent joints of 40% and with malunion non-union and impairment of function which was observed in 12.6% cases humerus fractures. **Conclusion**: About 16 cases were taken up for study and were followed up for 4-8 months form time since lnjury. Early functional activity with early restoration of joint movement reduced the period of rehabilitation considerably and the patient could resume their activities much earlier than those treated with other forms of conservative treatment. With these promising results, we hope to recruit more patients in a future prospective randomised trial, comparing our brace with other products or treatment interventions, with intent to demonstrate that our custom functional brace is economic, better tolerated by patients, and effective in treating humeral shaft fractures.

Key words: Functional cast bracing; closed fractures; fracture healing; humeral fractures

Introduction

Fracture of shaft of humerus is one of the commonest fractures seen in adults and accounts 3% of all fractures. Shaft or diaphysial fracture of the humerus is defined as extra articular fractures of humerus excluding 5 cm in each end [1, 2]. Conservative treatment was the only treatment for 5000 years. In last 100 years various operative techniques were developed and successfully used to manage difficult fractures. Initial classifications described are based mainly on locations and to some extent on morphology of fractures [3, 4]. Subsequently, AO classification combined them adequately but while treating them biological environments were paid less importance [1].

*Correspondence
Dr. Shekhareswar De
Assistant Professor, Department of Orthopedics, Shri Ramkrishna Institute of Medical Sciences and Sanaka Hospitals (SRIMS & SH), Malandighi, Kanksha, Durgapur, West Bengal, India
E-mail: deshekhareswar@gmail.com

The causes of humeral shaft fractures are road traffic accidents, simple fall and direct blow. It can be treated by different operative methods e.g. Closed nailing, dynamic Compression plating, external fixator etc. But operative management has their own complications.eg infection, radial nerve Palsy, vascular injury, pseudoarthrosis, delayed and non union [5]. In evaluating humerus injuries, classifying the fracture and, if necessary, reducing and immobilizing the fracture are essential. Eighty percent of proximal humerus fractures are nondisplaced or minimally displaced and, therefore, can be managed nonoperatively. Associated injuries are common in patients with osteoporosis. Proximal humerus fracture accounts for 6% of all fractures and is the third most common osteoporotic fracture, after the distal radius and vertebra. Approximately 85% of proximal humerus fractures occur in individuals older than 50 years. Distal humerus fractures are associated with ipsilateral proximal forearm fractures. In adults, fractures of the distal humerus account for approximately 2% of all fractures and a third of all humerus fractures. In younger individuals, these fractures are primarily caused by high-energy traumas; in the elderly, by low-energy falls [6-9].

The most common cause of proximal humeral fractures is a fall from standing, followed by motor vehicle accident and a fall involving

stairs. Additional mechanisms include violent muscle contractions from seizure activity, electrical shock, and athletic-related trauma. Proximal humeral fractures are most often closed. Causes of humeral diaphyseal fractures include a fall from standing, a motor vehicle accident, a fall from height, and pathology related. Distal humerus fractures are primarily caused by high-energy traumas, and in the elderly, they are most often caused by by low-energy falls [10, 11].

There is no commonly accepted opinion for the ideal treatment option for humeral shaft fractures [12]. In contrast to the compressing forces in lower extremity fractures resulting from the body weight and ground reaction forces, reduction can be achieved easily in humeral fractures thanks to the effect of the muscle tissue surrounding the humerus, and consequently, conservative treatment can be possible most of time [13].

Non operative treatment as the definitive method do not interfere with the biological environment at fracture site and provide more chance of union with fewer complications. Hospitalization can be avoided as the required procedure can be performed in outpatient department (OPD). Different methods such as hanging cast, U-slab have been successfully employed. But the technique of functional cast bracing described by Sarmiento is widely practice [15, 16]. In the present study the functional cast bracing was used and the clinical results were assessed.

Materials & Methods

This clinical study was done at a tertiary care teaching hospital, Durgapur, West Bengal. Approval from the Institutional ethics committee was obtained and written informed consent from the patient was taken. 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 [17]. 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. Sixteen cases of unilateral, closed humeral shaft fractures involving ten right arm and six left arm cases were included in this study, during April 2018 to March 2019. Only simple, closed diaphysial fractures were selected. Initially, fractures were stabilized by hanging cast for 7 to 10 days. Analgesic & anti inflammatory drugs (NSAIDS) were advised. Patients were called on 10th days for application of cast brace. Patient was made to sit on a stool. Hanging cast was removed. A thin layer of cotton padding was applied around his arm extending from shoulder to elbow. Now plaster cast was applied extending from just below the acromion and 2 cm. below the axilla to 1.5 cm above the medial epicondyle and laterally above lateral epicondyle. Gentle traction was applied and minor correction of alignment was done. Plaster cast was snugly applied so that it was neither tight nor loose and carefully moulded to match the contour of the limb. Cuff and collar sling was given with elbow at 90®. Patient was tanght to do active exercise of shoulder, elbow and wrist. Cases were followed up at 6, 8, & 10 weeks. Each patient was thoroughly examined and findings noted. Clinical union was concluded as no pain and motion at fracture site coupled with radiological evidence of callus formation at fracture site [Fig. 1-3].

Results

Table 1: Age distribution among study populations [n=16]

Age in year	No. of cases	Percentage
10-20	2	11.7%
21-40	8	53.2%
41-60	5	29.3%
61-70	1	5.7%

Age incidence of humeral shaft fractures in the series. Total no. of cases was 16 [Table 1]. Majority of the cases in the age group of 21-40 yrs (53.2%) followed by 41-60 yrs [29.3%].

Table2 : Distribution of affected sides among study populations [n=16]

Slide	No. of Cases	Percentage
Right	10	62.5%
Left	6	37.5%

About 62.5% cases right sides in comparison to 37.5% were left sided humeral shaft fractures [Table 2].

Table 3: Sex distribution among study populations [n=16]

Sex	No. of Cases	Percentage
Male	12	75%
Female	4	25%

Cases of humeral shaft fractures were more common in males (75%) in comparison to females (25%) [Table 3].

Table 4: Site of involvement of shaft

Site	No. of Cases	Percentage
Upper Third	2	12.5%
Middle Third	10	62.5%
Lower Third	4	25%

About 62.5% cases middle third involvement in comparison to 25% were lower third humeral shaft fractures [Table 4].

Table 5: Showing the types of fractures

Type	No. of Cases	Percentage
Oblique	6	37.5%
Transverse	5	31.3%
Spiral	3	18.7%
Comminuted	2	12.5%

About 37.5% cases were oblique fractures followed by 31.3% transverse and 18.7% spiral [Table 5].

Table 6: Showing mode of injury

Mode of injury	No. of cases	Percentage
RTA	10	62.5%
Fall	4	25.5%
Direct violence	2	12%

About 62.5% cases were due to road traffic accidents [RTA] followed by 25.5% fall and 12% direct violence [Table 6].

Table 7: Showing time of union in the series

Time of union	No. of Patients	Percentage
8 weeks	6	37.5%
10 weeks	6	37.5%
12 weeks	2	12.5%
>12 weeks Delayed Union	2	12.5%

About 75% cases were time of union followed noted 8-10 weeks by 25% cases time of union noted ≥12 weeks [Table 7].

Table 8: Showing functional end result of patient in the series

Result	No. of cases	Percentage
Excellent	5	31.2%
Good	6	37.5%
Fair	3	18.7
Poor	2	12.6%

Excellent means firm bony union without deformity and no limitation of motion and noted in 31.2% cases. Good means firm bony union, no functional impairment for ordinary purpose angulation not more than 10® and noted in 37.5% cases. Fair means firm bony union with occasional mild pain, limitation of motion in adjacent joint of more than 20% and angulation of more than 10® and recorded in 18.7% cases. Poor means persistent pain, limitation of motion in adjacent joints of 40% and with malunion non-union and impairment of function which was observed in 12.6% cases humerus fractures.

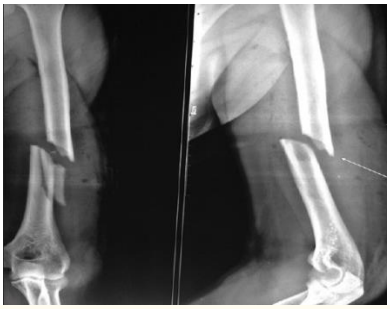

Fig 1: X-ray of left arm with shoulder joint showing fracture of left humeral shaft

Fig 2: X-ray of left arm with shoulder joint showing fracture of left humeral shaft

Fig 3: Abduction is observed here that movement is full when the brace is on.

Discussion

Proximal humerus fractures are more common in elderly persons, with the average age of 64.5 years [18, 19], and are the third most common fracture after hip fractures and distal radius fractures [7, 20]. Humeral diaphyseal fractures occur in a slightly younger population, with the average age being 54.8 years [20]. In adults, fractures of the distal humerus account for approximately 2% of all fractures and a third of all humerus fractures [10]. The most important clinical pearl associated with midshaft humerus fractures involves injury to the radial nerve. Radial nerve injury occurs in approximately 18% of closed mid-shaft or distal shaft humerus fractures. In closed fractures, radial nerve injury is most commonly an incomplete neuropraxia rather than a complete laceration of the nerve. In open humerus fractures, the incidence of radial nerve laceration is much higher at 60% [21-23].

In the present study a total of cases of 16 shaft humerus fractures. Majority of the cases in the age group of 21-40 yrs (53.2%) followed by 41-60 yrs [29.3%]. About 62.5% cases right sides in comparison to 37.5% were left sided humeral shaft fractures. Cases of humeral shaft fractures were more common in males (75%) in comparison to females (25%). About 62.5% cases middle third involvement in comparison to 25% were lower third humeral shaft fractures. About 37.5% cases were oblique fractures followed by 31.3% transverse and 18.7% spiral. About 62.5% cases were due to road traffic accidents [RTA] followed by 25.5% fall and 12% direct violence. About 75% cases were time of union followed noted 8-10 weeks by 25% cases time of union noted ≥12 weeks. Excellent means firm bony union without deformity and no limitation of motion and noted in 31.2% cases. Good means firm bony union, no functional impairment for ordinary purpose angulation not more than 10® and noted in 37.5% cases. Fair means firm bony union with occasional mild pain, limitation of motion in adjacent joint of more than 20% and angulation of more than 10® and recorded in 18.7% cases. Poor means persistent pain, limitation of motion in adjacent joints of 40% and with malunion non-union and impairment of function which was observed in 12.6% cases humerus fractures.

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. They concluded that average healing time is 10.7 weeks, 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 non-union [24].

M R Chandrashekaran study (2016) revealed that mean follow-up period was 40.5 months (range 15–62 months). At the removal of the cast brace, average union time of 50 patients was 10.1 weeks (range 6– 16 weeks). Average varus angulations were 9.1° (range 0–30°). Average rotation was 3° (range 0–15°). Average shortening was 0.51 cm (range 0–2 cm). The final results at 6 months were excellent in 44% (n = 22), good in 42% (n = 21), fair in 8% (n = 4), poor in 6% (n = 3). He concluded that functional brace treatment commenced immediately after injury is a viable alternative in the treatment of middle and lower third diaphyseal fractures of the humerus regardless of fracture configuration [25].

Athreya PJ et al study (2019) revealed that patients were initially managed with a U-Slab for an average of 26 days. Patients were followed up for an average of 70 days post brace application. 5 patients were lost to follow up. The remaining 11 patients had the brace on for an average of 73 days. In the last follow up, 15 patients had an acceptable anterior/posterior angulation of less than 20^0 (1 patient - 22^0), varus/valgus angulation less than 20^0, and less than 3cm of shortening. 12 patients had radiological evidence of union, with the other 4 demonstrating significant callus. 4 patients were recruited for prospective analysis with DASH, SPADI and CONSTANT shoulder scores, and demonstrated minimal loss of function. There were no complications of bracing treatment [26].

Sarmiento A et al study (2000) revealed that the functional brace was removed upon confirmation of clinical and radiographic union of the fracture, which occurred at an average of 11.5 weeks (range, five to

twenty-two weeks). Union was arbitrarily defined as being present when osseous bridging between the main fragments was observed on at least one radiograph and there was no pain at the fracture site. The 465 closed fractures healed at a median of 9.5 weeks (range, five to nineteen weeks) and the 155 open fractures, at a median of fourteen weeks (range, eight to twenty-two weeks). The median healing time was twelve weeks (range, eight to twenty-two weeks) for the 101 transverse fractures, ten weeks (range, five to seventeen weeks) for the 149 oblique fractures, eleven weeks (range, five to eighteen weeks) for the 364 comminuted fractures, and twelve weeks (range, eight to twenty-one weeks) for the six segmental fractures. The median healing time was ten weeks (range, five to fourteen weeks) for the ninety-two fractures located in the proximal third of the humeral diaphysis, ten weeks (range, six to twenty-two weeks) for the 303 fractures located in the middle third, nine weeks (range, six to twenty-two weeks) for the 219 fractures located in the distal third, and twelve weeks (range, eight to twenty-one weeks) for the six segmental fractures [27].

Conclusion

The concept of functional cast bracing and its application in the treatment of fractures is not new. Since Sarmiento (1977) reported his series many surgeon have successfully used this technique in the treatment of fractures of shaft of humerus. About 16 cases were taken up for study and were followed up for 4-8 months form time since lnjury. Early functional activity with early restoration of joint movement reduced the period of rehabilitation considerably and the patient could resume their activities much earlier than those treated with other forms of conservative treatment. With these promising results, we hope to recruit more patients in a future prospective randomised trial, comparing our brace with other products or treatment interventions, with intent to demonstrate that our custom functional brace is economic, better tolerated by patients, and effective in treating humeral shaft fractures. The factors need to be considered when treating such fractures, particularly in view of the rising cost of health care.

References

1. Muller ME, Nazarian S, Coch P, Schatzker JA. Berlin: Springer Verlag; 1990. Comprehensive Classification of Fracture of Long Bones.
2. Pal JN, Biswas P, Roy A, Hazra S, Mahato S. Outcome of humeral shaft fractures treated by functional cast brace. Indian J Orthop. 2015;49(4):408-417. doi:10.4103/0019-5413.159619
3. Wolter D, Zimmer W, editors. Adult Humeral Interlocking Nailing. Berlin: Springer Verlag; 1991.
4. Von Hansman bis Ilisarow. Plate osteosynthesis and its comparison with other methods; pp. 158–66.
5. Canale S T, Beaty J H. 11th ed. Ch. 54. Elsevier Mosby; 2007. Campbell's Operative Orthopaedic; p. 3389.
6. Kontakis G, Koutras C, Tosounidis T, Giannoudis P. Early management of proximal humeral fractures with hemiarthroplasty: a systematic review. J Bone Joint Surg Br. 2008 Nov. 90(11):1407-13.
7. Cheung EV, Sperling JW. Management of proximal humeral nonunions and malunions. Orthop Clin North Am. 2008 Oct. 39(4):475-82, vii.
8. Neer CS 2nd. Displaced proximal humeral fractures. I. Classification and evaluation. J Bone Joint Surg Am. 1970 Sep. 52(6):1077-89.
9. Shao YC, Harwood P, Grotz MR, Limb D, Giannoudis PV. Radial nerve palsy associated with fractures of the shaft of the humerus: a systematic review. J Bone Joint Surg Br. 2005 Dec. 87(12):1647-52.
10. Crean TE, Nallamothu SV. Distal Humerus Fractures. 2019 Jan.
11. Bounds EJ, Frane N, Kok SJ. Humeral Shaft Fractures. [Updated 2021 Jul 27]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan. Available from: https://www.ncbi.nlm.nih.gov/books/NBK448074/
12. Sarmiento A, Waddell JP, Latta LL. Diaphyseal humeral fractures: treatment options. Instr Course Lect 2002; 51:257-69.
13. Sarmiento A, Horowitch A, Aboulafia A, Vangsness CT Jr. Functional bracing for comminuted extra-articular fractures of the distal third of the humerus. J Bone Joint Surg [Br] 1990; 72:283-7 3.
14. Balfour GW, Mooney V, Ashby ME. Diaphyseal fractures of the humerus treated with a ready-made fracture brace. J Bone Joint Surg [Am] 1982;64:11-3.
15. Sarmiento A, Kinman PB, Galvin EG, Schmitt RH, Phillips JG. Functional bracing of fractures of the shaft of the humerus. J Bone Joint Surg Am. 1977;59:596–601.
16. Papasoulis E, Drosos GI, Ververidis AN, Verettas DA. Functional bracing of humeral shaft fractures. A review of clinical studies. Injury. 2010;41:e21–27.
17. Gustilo RB, Mendoza RM, Williams DN. Problems in the management of type III (severe) open fractures: A new classification of type III open fractures. J Trauma. 1984;24:742–6.
18. Brown CC, McQueen MM, Tornetta III P. Orthopedic Surgery Essentials: Trauma. Philadelphia, Pa: Lippincott Williams and Wilkins; 2006. 89-114.
19. Grawe B, Le T, Lee T, Wyrick J. Open Reduction and Internal Fixation (ORIF) of Complex 3- and 4-Part Fractures of the Proximal Humerus: Does Age Really Matter?. Geriatr Orthop Surg Rehabil. 2012 Mar. 3(1):27-32.
20. Baron AA, Barrett JA, Karagas MR. The epidemiology of peripheral fractures. Bone. 1996. 18:209S-13S.
21. Laulan J. High radial nerve palsy. Hand Surg Rehabil. 2019 Feb;38(1):2-13.
22. Martin AR, Gittings DJ, Levin LS, Donegan DJ, Gray BL. Acute Radial Nerve Repair with Humeral Shaft Shortening and Fixation Following a Closed Humeral Shaft Fracture: A Case Report. JBJS Case Connect. 2018 Oct-Dec;8(4):e109.
23. Agarwal A, Chandra A, Jaipal U, Saini N. A panorama of radial nerve pathologies- an imaging diagnosis: a step ahead. Insights Imaging. 2018 Dec;9(6):1021-1034.
24. Papasoulis E, Drosos GI, Ververidis AN, Verettas DA. Functional bracing of humeral shaft fractures. A review of clinical studies. Injury. 2010;41:e21–27.
25. M R Chandrashekaran. Clinicoradiological and Functional Outcome of Humeral Shaft Fractures Treated by Functional Cast and Brace: A Hospital Based Study. Int J Med Res Prof. 2016, 2(1); 175-77.
26. Athreya PJ, Abbott V, Elias L, Thomas B. Evaluating the Outcome of a New Functional Brace for the Management of Humeral Shaft Fractures. The Open Orthopaedics Journal 2019; 13:136-143.
27. Sarmiento A, Zagorski JB, Zych GA, Latta LL, Capps CA. Functional bracing for the treatment of fractures of the humeral diaphysis. J Bone Joint Surg Am. 2000 Apr;82(4):478-86. doi: 10.2106/00004623-200004000-00003. PMID: 10761938.

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