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Case Study

A Novel Fracture Bracing for Humeral Diaphyseal Fracture Associated with Radial Nerve Palsy

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ABSTRACT

Background: widely accepted treatment of humeral diaphyseal fracture is functional fracture bracing but the results are inconsistent in the presence of an associated radial nerve palsy complication.
Objective: to design a new functional fracture bracing that would combinedly address the humeral fracture along with the associated radial nerve palsy complication.
Study design: a prospective observational study.
Methods: Site of the fracture was identified and an adjustable humeral sleeve made up of orthograde polymer ranging below the acromion to well above the humeral epicondyle was fabricated. A dorsal cockup splint for radial nerve palsy ranged just below the elbow to MTP joint. Both the portions were hinged together at elbow joint to act as a single unit. The patient was followed prospectively for12 weeks and adjacent joint range of motion and hand grip strength were recorded.
Result: At the end of 12th week fracture had united, shoulder and elbow joint range of motion recovered to 90-98% when compared to the normal side and gradual recovery of hand grip strength reached to 47kg (same as the normal side).
Conclusion: associated radial nerve palsy can be managed conservatively along with the primary humeral diaphyseal fracture by this new functional fracture bracing.

Key words: Humeral fracture bracing, Functional Fracture Bracing, Conservative fracture treatment.

INTRODUCTION

Fracture bracing is based on the philosophy that the increased physiological mobility and limiting unnecessary adjacent segmental limitations induces osteogenic activities at fracture site hence imparting better fracture healing[1]. The functional fracture bracing dates back to the 1970s, has since then evolved as popular treatment option for diaphyseal fractures of long bones[2]. The fracture bracing, despite its advantages is only applicable to classical case of long bone diaphyseal fractures without any soft tissue injury and no communition. The principle of fracture bracing based on the premise of creating a *pseudo hydrostatic* pressure around the fracture site through the compression of soft tissues and muscles[3]. This pseudo *hydrostatic* claimed to be the stabilizing force that maintains the fractured segments in close proximity and help forming the soft callus. Minor shortenings, angulations and rotations that occur during healing process are not major limiting factors but are mere deviations from the normal. These deviations are usually masked by the soft tissues around and are inconsequential if not a hindrance to the daily activities. The humeral diaphyseal fractures enjoy the greater rate consistent satisfactory results from the functional fracture bracing[4, 5]. Tolerance of humeral diaphyseal fracture to the post correction deviation is most. A Varus angulation of 15 degrees in normal adults to 25-30 degrees of Varus angulations in flabby patients is inconsequential and well masked[6]. Radial nerve palsy is one of the complications associated with the humeral diaphyseal fractures and end up with a wrist contracture if not addressed meticulously. Results of humeral diaphyseal fracture alone treated with functional fracture bracing are overwhelming but presence of associated radial nerve palsy has poor evidences[7]. The rationale of this poor prognosis may be due to the failure of early diagnosis and nerve entrapment in callus which requires surgical attention. There is no such orthotic device that can address both humeral diaphyseal fracture and associated radial nerve palsy complication. So aim of this study was to design an orthotic device that will provide stabilization to the fracture site and augment the wrist extensors by their active mobilization.

METHODS

Subjects

The subject was a 21 year old male who acquired a low energy humeral fracture during a road traffic accident and was referred to the Ishwar institute of prosthetics and orthotics for the functional fracture bracing after a duration of 2 week of time interval. The subject was conservatively managed by an above elbow cast and fractures site was devoid of any edema. On detailed evaluation of the subject, an associated radial nerve palsy was diagnosed which was initially missed during the emergency orthopedic care. A retrospective narrative confirms the onset of radial nerve palsy to be at the time of injury. The pain level of the patient was measured by using Visual analog scale (VAS) ranged 0-100mm, where 0ndicative of the no pain and 100indicatedive of worst pain imaginable.

Fabrication procedure

1. *Evaluation*

On arrival in the organization the subject was stable and initial inflammatory symptoms had subsided. The patients have acquired the secondary radial nerve palsy apart from the primary humeral fracture.

2. *Limb impression technique*

Arm casting: Cast were wrapped from 2 to 3 inches above the acromion process to 2 to 3 inches below the lateral epicondyle Forearm casting: In this phase cast were wrapped from 2 to 3 inches above from the lateral epicondyle to the tip of the thumb

3. *Modification procedure*

Modification procedure started with the removal of extra hanging material if any, then followed by strengthening of important landmarks that needs to be specially taken care of and followed by checking of measurements to exclude the possibility of any major cast deformation during the process of pouring. No any major modification was done rather a uniform smoothening of the mould was done to ensure proper fit to the anatomical extremity and bony prominence was relieved by addition of material.

4. *Draping process and attachments*

Both the arm shell and forearm shell were draped separately as mould for both arm and forearm were separate. Suction molding ensured that every important landmarks and modifications were properly transferred to the polypropylene shell. In following steps shells were given final finishing so that edges of shells do not hamper the fit and patient gets utmost comfort (figure:1). Subsequently both the arm and forearm shells were assembled together by the help of a simple hinge in order to maintain the simplicity of the design and function. (Figure: 2)

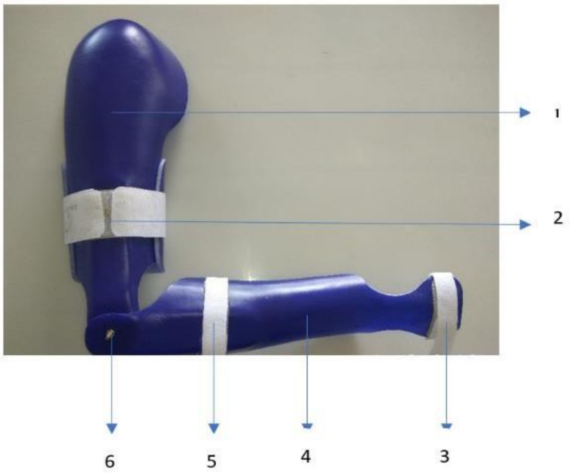


Figure 1: New humeral functional fracture brace
{Parts of the fracture brace are Arm shell1, Straps (arm shell)2, Straps (over the wrist)3, Forearm shell4, Straps (over the forearm)5, Elbow joint 6}

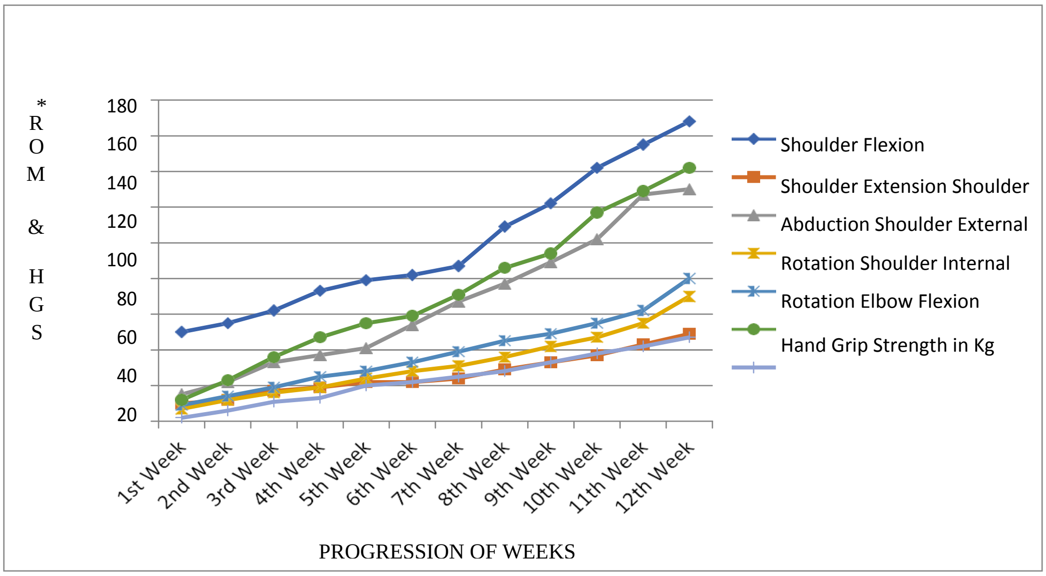
Figure 2: Patient maintained in functional position (Elbow 90°)

RESULT

With the novel humeral fracture brace the patient was followed prospectively for12 weeks (Table no: 1). To evaluate the fracture brace's dynamic nature (to allow mobilization), gradual change in subjects shoulder and elbow range of emotions were collected, as an increase in adjacent joints ROM indicative of a functional brace. Hand grip strength was measured over a span of 12 weeks by a hand dynamometer in kg. An increase in hand strength was considered indicative of radial nerve recovery as wrist extensor muscles act on stabilization of the wrist in extension during activities of grip and pinch. A considerable recovery of joint range of motion was recorded ranging from 90-98% (Graph: 1) of total normal joint range of motion. Hand grip strength nearly matched the opposite site (47 kg), although some residual weakness still persisted and it was postulated that further muscle activity will improve the hand grip further. Pain level was measured again with the VAS and result was satisfactory. Most importantly the fracture site has united with signs of the fifth feature was bridging, which was defined as the loss of fracture line definition with complete bridging of the fracture gap by a soft or hard callus. Remodeling has started with the Shape of the fracture site returning to that of original one.

Table 1: Improvement in joint range of motion and hand grip strength during 12 weeks

No .of Weeks	Shoulder Flexion	Shoulder Extension	Shoulder Abduction	Shoulder External Rotation	Shoulder Internal Rotation	Elbow Flexion	Hand Grip Strength in Kg
1st Week	50°	10°	15°	7°	9°	12°	2kg
3rd Week	62°	17°°	33°	16°	19°	36°	11 kg
5th Week	79°	22°	41°	24°	28°	55°	20 kg
7th Week	87°	24°	67°	31°	39°	71°°	25 kg
9th Week	122°	33°	89°	42°	49°	94°	33 kg
11th Week	155°	43°	127°	55°	62°	129°	42 kg
12th Week	168°	49°	130°	70°	80°	142°	47 kg



*ROM=Range of motion and HGS=hand grip strength

Graph 1: Progression of joint ROM and Hand grip strength in 12 weeks. (ROM=Range of Motion in degrees, HGS=Hand Grip Strength in kg)

DISCUSSION

Trauma care principle is based on treating primary orthopedic emergencies first on priority basis as these are often life threatening. Once the patient is stable, conscious and inflammatory phase has subsided, a meticulous assessment of the patient needs to be carried out in order to find out any secondary orthopedic conditions like subluxation and nerve impairments that might have missed during emergency care and should be dealt with equal importance.

Besides the success rate of functional fracture bracing of humeral diaphysis, often it gets complicated with associated radial nerve palsy. So, in this study a new design of fracture bracing having a humeral sleeve hinged with a dorsal cock-up splint was able to address both the orthopedic condition simultaneously.

This functional fracture bracing is unrestrictive and allows for adequate mobilization of adjacent joints to the fracture site. For the best results the fracture bracing should be combined with the therapeutic ROM exercises as physiological mobilization is postulated to induce osteogenesis. Marked increase in JROM over the follow-up period suggests functional nature of the brace.

Proximal Humeral sleeve portion of the brace should be adjustable in nature to accommodate volume fluctuation of soft tissues during various phases of the fracture healing. It is to be ensured that the humeral sleeve should always be snugly fitted to the fractured site to maintain the hydrostatic pressure required for stability of fractured ends.

In this study distal dorsal cock-up portion acts as an out trigger for functional mobilization of impaired wrist. Marked increase in hand grip strength in the study is an indirect indicator of wrist extensor recovery.

CONCLUSION

Humeral diaphyseal fractures without any soft tissue involvement and non communition should always be managed conservatively with functional fracture bracing considering its success rate and cost effectiveness. Recent advancement of intramedullary nailing technique of fracture management of long bones has surely given an alternative choice of treatment. So further clinical studies needs to be conducted for improving clinical decision making, comparing efficacy and to avoid confusion during prescription between two from of alternative treatment.

Learning from this article

In a less resourced setting where the availability and affordability of the components and materials poses a challenge, the best possible attempt is to be made for service delivery to the patient with available resources without compromising the safety of patient.

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Authors' contributions:

The entire clinical course of functional fracture bracing service delivery was done by Mr. 2Jegadeesh M towards the fulfilment of bachelor degree research project under the supervision of Mr. 1Bapina Kumar Rout. Subsequent data collection and manuscript preparation is done by Mr. 1Bapina Kumar Rout. All the clinical service delivery to patient and research study was carried out in the premises of Ishwar institute of prosthetics and orthotics, an institute that imparting learning and patient service delivery.

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