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FUNCTIONAL BRACING OF FRACTURES OF THE SHAFT OF THE HUMERUS


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ABSTRACT: We treated fifty-one cases of fracture of the shaft of the humerus with a functional method of treatment consisting of a plastic sleeve, individually molded or prefabricated. It maintained good alignment of the fragments and permitted rapid and uninterrupted osteogenesis. The early introduction of functional activity to the entire extremity appears to provide a desirable physiological environment conducive to rapid healing. Non-unions have not been encountered in non-pathological fractures. Healing time has been rapid, and there has been consistent restoration of motion of all joints prior to the completion of healing. The morbidity was minimum.

Fractures of the shaft of the humerus are relatively infrequent and usually do not constitute a major therapeutic problem. Non-surgical management is preferred because non-union is rare, healing time is short, and infection is uncommon. Even some of the most ardent advocates of compression osteosynthesis recognize that "better results after conservative treatment prove that uncomplicated fractures of the humeral shaft should not be primarily approached by open reduction." However, non-surgical management of these fractures is associated with some morbidity and undesirable sequelae. Non-union is not a frequent complication but it does occur in from 1 to 12 per cent of patients. Loss of motion of the shoulder from adhesive capsulitis or from a transient subluxation of the shoulder may cause an important disability during healing and afterward. All types of conservative therapy have disadvantages as well as advantages. Any effective device — even a hanging cast, coaptation u-splints, or a Velpeau bandage — limits a patient in daily activities. A long period of rehabilitation may be needed to restore motion to the immobilized joints.
The satisfactory results obtained by functional bracing of tibial, femoral, forearm, and Colles fractures developed at the University of Miami School of Medicine stimulated us to extend this method of treatment to fractures of the shaft of the humerus.

**Technique**

For all of the fifty-one fractures under review, the initial treatment was stabilization either by use of a hanging cast, sugar-tong splints, or a Velpeau bandage or by application of skeletal traction. We preferred the hanging cast or sugar-tong splints and encouraged patients to start range-of-motion exercises of the shoulder as soon as possible.

When the acute pain and swelling subsided, the functional brace was applied. As our experience and confidence with this method increased, the brace was applied earlier after injury and presently most patients receive it within the first week of injury (Fig. 1). Originally Orthoplast (Johnson and Johnson) sleeves were molded individually. With experience a prefabricated polypropylene sleeve became the routine appliance we used. It is available in two sizes, and simple modifications can be made to accommodate any patient who is hard to fit (Fig. 1). The sleeve extends medially from 2.5 centimeters below the axilla to 1.3 centimeters above the medial epicondyle of the humerus. Laterally, it extends from a point just below the acromion to slightly above the lateral epicondyle. During application of the sleeve, minor correction in the alignment of the fragments can be carried out. The sleeve must allow a complete range of motion of the shoulder and elbow. The Velcro straps permit removal of the splint for personal hygiene and for adjustment of the compression of the soft tissues as the edema subsides.

A shoulder harness may be attached to the proximal portion of the splint and looped around the neck to prevent slippage of the sleeve downward. This is likely to occur in patients with large and flabby extremities.

Following the application of the custom-made or prefabricated sleeve, an arm sling was applied holding the elbow at 90 degrees of flexion. Patients were encouraged to do active and passive motion exercises for all joints of the fractured extremity. Extension of the elbow was gained gradually as the pain subsided. Within a few weeks nearly every patient could touch his face with his hand and activities of daily living could be performed with minimum difficulty. Approximately one week after the application of
the sleeve, pendulum exercises with the elbow in extension were begun. Spontaneous correction of angulatory deformities was observed following the initiation of such exercises. When roentgenographic and clinical evidence of good callus formation was demonstrated, the splint was removed for periods of time.

**Case Material**

We treated forty-nine patients with fifty-one humeral shaft fractures with the functional brace just described. Twenty-eight patients were male and twenty-one were female. One patient had bilateral fracture and one had a second fracture below an already healed fracture. The ages of the patients ranged from fourteen to seventy-five years, with a median of thirty-eight years. Thirteen fractures were open and thirty-eight, closed. Twenty-seven fractures involved the left humerus and twenty-four, the right. The fractures occurred as a result of vehicular accidents in nine instances (18 per cent); twenty-eight were the result of falls (56 per cent); eleven were gunshot wounds (22 per cent); and three were twisting injuries (4 per cent). Two fractures were pathological (metastatic carcinoma of the breast). One patient had been receiving chemotherapy at the time of the injury, and a non-union developed that required open reduction and internal fixation.

There were nine fractures of the proximal third of the humerus (18 per cent), twenty-six of the middle third (50 per cent), and sixteen of the distal third (32 per cent).

The initial method of immobilization was traction (6 per cent), a Velpeau bandage (6 per cent), a sugar-tong splint (42 per cent), or a hanging cast (46 per cent). The time of this stabilization ranged from four to ninety-seven days (average, eleven days). The arms remained in the sleeve until the fractures were clinically and roentgenographically healed. Healing was determined on the basis of absence of pain and motion at the fracture site and good callus formation as demonstrated roentgenographically (Figs. 2-A through 4-C). The time from injury to discontinuance of the sleeve ranged from three to 22.5 weeks, with a median of 8.5 weeks and a mode of seven weeks.
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The only non-union occurred in a patient with metastatic carcinoma of the breast. Follow-up ranged from two to thirty months after removal of the sleeve. Minimum limitation of motion was detected at final examination — mostly a loss of the last few degrees of external rotation. All but nine of the patients had full elbow and shoulder motion at the time of removal of the sleeve. Those nine lacked 15 degrees or less of abduction or rotation of the shoulder. The average angulation of the fragments was 4 degrees, and the most common deformity was varus. Eight patients had 10 to 20 degrees of angular deformity. The remaining patients had less than 5 degrees of angulation. Six patients (12 per cent) had an associated initial radial-nerve palsy from which they recovered spontaneously.

Three patients (6 per cent) had associated vascular injuries. They were treated initially by débridement, vascular repair, and skeletal traction.

Discussion

Our experience during the past thirteen years with functional bracing for treatment of fractures of long bones of the appendicular skeleton leads us to assert that rigid immobilization of fracture fragments, adjacent joints, or both is not a necessary prerequisite for fracture healing. It...
healing\textsuperscript{21,23,27}. Firm compression of the soft tissues surrounding the fractured bone is applied by the rigid walls of the brace or sleeve and adequate alignment of the fragments is maintained with sufficient stability to permit uninterrupted osteogenesis\textsuperscript{21,27,28}. Our own laboratory studies have also indicated that the functional activity which is maintained during the reparative process results in large periosteal callus of greater mechanical strength than the callus of similar fractures treated by restricting the activity of the extremity\textsuperscript{30}. The bulkiness of the periosteal callus frequently found in fractures that heal in the presence of function does not interfere with joint motion and remodeling takes place in a consistently rapid fashion.

Others have shown that up to 30 per cent of angulation following a humeral fracture is cosmetically and functionally acceptable. The bulk of the muscle of the arm and the wide ranges of motion of the shoulder and elbow tend to hide the bone deformity\textsuperscript{4,11-13,15}. The minimum rotatory deformities we found in our patients, although difficult to measure, did not result in limitation of pronation or supination of the forearm.

Just after the sleeve was applied, swelling of the arm distal to the sleeve was encountered on occasion, particularly in those patients who had the sleeve applied within a few days of the injury. In no instance, however, was the swelling a problem. The active and passive use of the extremity instituted shortly after the application of the sleeve seems to have resulted in gradual disappearance of the edema.

### References