Fracture bracing of the lower extremity, which has been used successfully since the 1970s, has taught clinicians that protected early motion and weight bearing stimulate strong bone formation. August Sarmiento, the primary proponent of fracture bracing, first developed successful strategies for fracture bracing of the lower extremity and later developed applications for the upper extremity. The advantages of early motion in preventing disability and stimulating bone healing demonstrated a decreased need for long periods of fracture immobilization. Simultaneously, developments in hand surgery and hand therapy led to shorter periods of immobilization, which supported the use of fracture bracing in selected stable upper extremity fractures.

Fracture bracing stabilizes long bone fractures of the humerus and forearm by compressing surrounding muscle and soft tissue. The cylinder-shaped brace provides a stabilizing force equal in all directions, which limits motion at the fracture site. Fracture healing in the presence of limited motion is also applied to selected stable fractures of the metacarpals and phalanges. In hand fractures, compression of soft tissue other than muscle provides the needed stabilizing support during active motion.

Many terms have been used to describe the fitting of an external device to stabilize a fracture; the term fracture bracing is used throughout this chapter. Initially, plaster casts with connecting hinges applied to femoral fractures were called cast braces. The use of plastic materials for these cast braces led to the term fracture brace. Sarmiento prefers the term functional fracture bracing because it more accurately reflects the primary advantage of this technique: maintenance of joint motion and muscle function while reducing costs, rehabilitation time, and surgical complications.

**History**

For many years, the teachings of Hippocrates encouraged physicians to immobilize the joints above and below a fracture, believing this was required for fracture healing. In 1767, Gooch described tibial and femoral functional fracture braces, but the concept remained obscure for the next two centuries, until in the 1970s Sarmiento left the ankle free in a tibial cast and created the first modern functional brace.
He demonstrated the advantages of early functional motion and led a renaissance of treatment techniques based on a new idea: early motion facilitates bone healing. The availability of thermoplastic orthoses and a new generation of casting materials has greatly advanced the popularity of this technique.

Any technique that lessens the period of disability and reduces complications must be considered the treatment of choice. Colton has succinctly described the advantages of functional fracture bracing: “The widespread use of functional bracing has liberated countless patients from prolonged hospitalization and permitted early return to function and to gainful employment.”

Principles of Fracture Bracing

Bone Healing

The observation that the clavicle and the ribs heal without complication in the presence of motion provides the evidence that fractures do not need to be immobilized to heal. This knowledge has caused us to examine more closely the two ways in which bone heals. Primary healing occurs in rigidly immobilized fractures; secondary healing occurs when there is motion at the fracture site.

In primary healing, accurately approximated bone ends encourage the formation of medullary callus. Because the diameter of this callus is small, the callus is mechanically inferior to the callus of a fracture that is allowed to move during healing. When bone heals secondarily, periosteal callus forms around the fracture site, creating a larger and stronger external callus. In its early stages this callus is pliable, but as it matures it provides increasing stability to the fracture as tissue differentiation occurs. This periosteal callus formation is stimulated by motion at the fracture site, although excessive motion is detrimental to healing. The bone ends moving on one another create a vascular reaction, stimulating capillary invasion from the soft tissue to the fracture site, which in turn causes prolife osteogenesis and more rapid union. The rapid healing of fractures with exuberant callus formation in patients with involuntary motion caused by cerebral irritation is partially attributed to frequent motion occurring at the fracture site. Periosteal callus is stronger not only because it is larger in diameter but also because the stress of motion is directed to the periphery of the callus. Thus bone forms in the periphery of the callus before it forms in the center, accounting for the early strength of secondary fracture healing. Rigid immobilization inhibits production of external callus. The purpose of a functional fracture brace is to provide fracture alignment stability but not rigid immobilization of the bone ends. Because bone deprived of stress undergoes atrophy, proponents of fracture bracing believe that prolonged rest and immobilization of joints above and below a fracture are actually detrimental to fracture healing. Although the trabeculae of the bone return to normal anatomy more quickly in rigidly immobilized fractures, functional motion supported by the bone occurs much more quickly when external callus forms. It is the “controlled” motion within the fracture brace that is the desirable stimulus to healing.

Design Principles of Fracture Braces

Functional fracture bracing is accomplished by applying an external cylinder around a fractured long bone. This cylinder restrains soft tissue expansion, directing force equally in all directions internally during muscle contraction. As muscles contract within the rigid cylinder, their attempted increase in size is translated into compressive forces within the cylinder. Sarmiento describes this as a pseudohydraulic environment. This internal force mechanically stabilizes the fracture. The concept of soft tissue containment does not depend on the strength of the cylinder material, but rather on the inherent size and shape of the cylinder. The cylinder allows consistent pressure to be exerted on the fracture during active muscle contraction.

The ability of soft tissues to provide stability was shown dramatically by Zagorski and colleagues when they wrapped a piece of meat around a metal hinge and provided external compression by wrapping it with a piece of brown paper. Circumferential brown paper increased the rigidity of the hinge nearly 100 times. Using Orthoplast orthotic material further increased the rigidity only two times over the brown paper, proving that the cylinder shape and not the material rigidity provides fracture stability. Latia and coworkers demonstrated in lower-leg fractures that more than 80% of the load placed on the limb is borne by the soft tissues. They stated, “The brace is not the major load bearing structure.” Because functional fracture bracing stabilizes but does not immobilize fractures, it is most effective in the treatment of fractures in which initial shortening is within acceptable...
limits. Most commonly these are closed, low-energy fractures that require little or no reduction. The cylinder shape of the fracture brace is more effective in controlling angulation than rotation or length at the fracture site. The external brace limits but does not totally prevent motion at the fracture site. When the muscles are at rest the brace creates equal compression of the soft tissues. This compression encourages the bone to return to its initial position, preventing progression of deformity.

Although many authors have written about early motion in metacarpal and phalangeal fractures, the absence of bulky muscle tissues in the hand prevents the principles of fracture bracing from being literally applied. The principle of soft tissue support does apply, although it is the finger flexors and dorsal hood mechanism that supply stabilizing forces for selected fractures of these bones. This principle is discussed in greater detail later in this chapter.

**Contraindications for Functional Bracing**

Fractures that are accompanied by major soft tissue injury or bone loss clearly do not have the necessary soft tissue support, so other means of stabilization are required for these types of fractures. Uncooperative and unreliable patients are thought to be poor candidates for fracture bracing, perhaps because of the attention needed for skin care and hygiene. As previously stated, only fractures with minimal displacement, shortening, or angulation can be adequately treated by this technique.

**Humeral Fractures**

The humerus, being a single long bone in the upper arm, is an ideal candidate for functional fracture bracing. The brace ideally compresses the bulky biceps and triceps muscles, allowing early shoulder, elbow, wrist, and hand motion (see Fig. 127-1). Clinical experience has shown that humeral shaft fractures have a high rate of healing with excellent return of function, except those fractures complicated by radial nerve palsy. There is also some evidence that fractures in the distal third of the humerus have a lower healing rate than more proximal fractures of the humerus. Unlike the smaller bones of the forearm and hand, less than full anatomic reduction of the humerus can accompany a full functional result.

In addition to humeral shaft fractures, distal humeral fractures also may be managed by fracture bracing. A hinge is sometimes used at the elbow to allow elbow flexion and extension but prevent varus-valgus and translational forces (Fig. 127-2). Good results have also been reported without use of the hinge. Proximal humeral fractures also can be treated effectively with the circumferential brace, even though it does not encompass the fracture. The compression of the soft tissue provides enough stabilizing force to stimulate healing. Thus the use of a fracture brace is effective regardless of the level of the humeral fracture.

Some authors advocate immediate fitting of the plastic brace over cast padding. Patients generally are treated with a plaster coaptation orthosis (anterior and posterior plaster slabs held in place with an elastic wrap) until the swelling and pain have subsided. The humeral fracture brace is then fitted 7 to 10 days after injury, when edema and pain are diminished.

Long periods of immobilization of the injured upper extremity are fraught with complications caused by stiffness. These complications often necessitate extended periods of rehabilitation. Fracture bracing of the humerus provides stabilization of the fracture while shoulder and distal joint motion is maintained. All of the muscles crossing the humerus (biceps, triceps, and brachialis) run parallel to the long axis of the humerus. Active contraction of these muscles reestablishes accurate alignment and rotation; this explains why functional deformities are rare in the presence of active motion. Sarmiento and colleagues describe spontaneous correction of angulatory deformities after shoulder pendulum motion and elbow motion in their review of 51 humeral fractures.

Initially, for comfort and support, an arm sling is applied in addition to the fracture brace. The sling is removed frequently for exercises, and as callus formation provides increasing stability the sling is discontinued. The increasing comfortable range of motion (ROM) allows use of the injured arm for assistance with self-care and activities of daily living. The plastic fracture brace must be removed daily for skin hygiene, application of a clean stockinet liner, and optional application of cornstarch or baby powder to retard perspiration. Stockinet under the brace acts as an efficient liner to reduce skin friction and to absorb perspiration.

Patients are often apprehensive about removal of the brace at home. They should be instructed to sit in an armless chair, supporting the injured arm in the lap with the elbow flexed. The patient then leans the trunk toward the injured side, thus allowing the arm to hang freely. This creates room between the body and the arm to allow an assistant to comfortably remove the brace. Patients experience no pain during removal of the brace if the muscles in the injured arm remain fully relaxed and gravity maintains longitudinal alignment. However, active abduction of the humerus results in painful motion at the fracture site.

Most authors agree that certain exercises should be started immediately after the application of the cast, and some also advocate immediate passive exercise. I prefer an early focus on active pendulum exercises together with active flexion and extension of the elbow, as well as active resistive
finger flexion. External rotation of the shoulder or active or passive abduction of the shoulder encourages external rotation or angulation of the distal fracture fragment, so these positions must be avoided. The patient should be instructed to keep the hand near the midline of the body when the elbow is flexed or at the side of the body when the elbow is extended (except during pendulum exercises). The arm should not be abducted away from the body, nor the elbow propped on a surface, nor a pillow or other object placed between the arm and the body.

Initially, the frequency of exercises is limited by the patient's pain and apprehension. Within 1 week of fracture brace application, the patient should be able to comfortably exercise two to four times daily. Sarmiento suggests avoidance of early active shoulder flexion and abduction exercises until fracture stability has developed because he believes that these exercises contribute to angulation. He states that pendulum and circumduction are the only exercises necessary during the first few weeks. Surgeons experienced with the use of functional bracing for humeral shaft fractures agree that hand therapy usually is needed only in the first few weeks after fracture, unless there are other concomitant injuries or complications.

**Construction and Application**

**Humeral Shaft Fracture Brace**

The design of the humeral fracture brace must allow full shoulder and elbow ROM, and therefore designs with shoulder caps should be avoided (Fig. 127-3, online). A one-piece circumferential design with an overlapping long edge made of a thin thermoplastic orthotic material (1/8-inch thickness) is ideal to provide tissue compression. This material is flexible enough to allow easy application and removal of the brace and also to accommodate the decreased circumference as edema subsides (Fig. 127-4, online). Radiographic examination of the fracture is facilitated by the radiolucent plastic materials used to construct the brace.

The cylinder is closed with a circumferential hook-and-loop-strap with a D-ring component. This strapping configuration allows the patient to securely close the cylinder and easily adjust the tension with one hand (Fig. 127-5).

Circumferential braces made of thicker and more rigid materials allow more unwanted angulation. To avoid this problem, some advocate a brace with anterior and posterior components. Only if the material itself is rigid is this two-part design necessary to provide adequate soft tissue compression. Applying a two-part brace so the two pieces sit opposite over the apex of the angulation minimizes the final angulation. Sarmiento and colleagues have demonstrated a progression from a relatively rigid one-piece polypropylene brace to a more compliant polyethylene brace. The soft tissue must be entirely encircled by the flexible brace to respect the basic principle of soft tissue encasement and to provide adequate stability and compression.

Both custom and prefabricated braces have proven effective in stabilizing the humeral shaft, although care must be taken to ensure accurate fit and compression with prefabricated braces (see Figs. 127-3, online, and 127-6). Some authors complain of the time-consuming, expensive fitting of the brace when fabricated by an orthotist. The high-temperature permanent materials used by orthotists are unnecessary in the uncomplicated humeral fracture because the fracture brace is worn for a relatively short time. Therapists who frequently construct orthoses can, in one office visit, easily construct and fit a cost-effective humeral fracture brace from a low-temperature thermoplastic material as well as instruct patients in early motion exercises. Additionally, if early problems arise with edema or orthosis fit, the therapist...
is the referral of choice for solving such problems. The application of a circumferential hook-and-loop strap with D-ring closure allows the patient to adjust the brace consistently for steady pressure and to decrease the size of the brace as edema subsides. Initially patients are prone to tighten the brace excessively in an attempt to prevent the movement of the bone fragments. It is helpful to explain to the patient that this sensation is normal and not detrimental, since excessive tightening of the brace results in increased distal edema. The brace must be fitted with the patient's arm completely relaxed, allowing gravity to assist in alignment of the fragments. Patients usually react by contracting their muscles to hold the arm still. With a fractured humerus, this muscle contraction causes the deltoid to pull on the proximal fragment, increasing angulation and causing pain. Asking the patient to lean the torso laterally (toward the involved side) approximately 30 degrees from vertical allows the arm to hang vertically while providing room for the therapist to work between the arm and body (Fig. 127-7, online). The patient holds the hand of the injured arm in his or her lap with the uninjured hand, allowing the elbow to rest at a 90-degree angle.

The low-temperature thermoplastic materials may be molded directly to the patient's arm, and gentle molding can provide minor correction of angulation (see Fig. 127-7, online). Radiographs must be available to the therapist so that molding may be directed toward the apex of the angulation, if applicable. If the patient is a large-breasted female, it may be necessary to position the breast tissue out of the way by wrapping the torso with a wide elastic wrap while the brace is being molded.

**Distal Humeral Fracture Brace**

The incidence of distal humeral fractures appropriate for functional fracture bracing is low. Most often, these distal fractures require open reduction and internal fixation, and the fracture brace is used postoperatively for additional protection (see Fig. 127-2).

The humeral portion of the fracture brace is molded as described previously. Particular attention must be given to accurately mold the brace as far distally as possible and still allow full elbow motion. A circumferential forearm brace is then molded with the forearm usually positioned in neutral. The location of the elbow hinges is determined while the proximal and distal braces are temporarily held in place with adhesive tape. Care must be taken to move the elbow through partial ROM while positioning the hinges to ensure they are at the axis of joint motion. For ease of application and removal of the brace as well as to allow room for hinge application, the opening of both the humeral and forearm pieces should be anterior. Hook-and-loop closures are applied to both sections after hinge application.

**Problems and Complications**

Plastic materials are occlusive to the skin, and frequent removal and skin care are necessary to prevent skin maceration. Patients with poor hygiene habits or who are anxious about removal for skin care are more likely to develop skin problems. Obese patients with excessively flabby arms and females with excessive breast tissue are challenges for accurate fitting. A large breast acts as a fulcrum to encourage angulation at the fracture site. Ironically, excessive soft tissue of the arm camouflages fracture angulation, so any residual angulation is rarely noticed or perceived as a functional problem.

Edema distal to the brace is a common finding but rarely a long-term problem. As the patient's comfort increases and active motion returns, edema recedes unless there is concomitant distal injury to the arm or hand. The application of an elastic stockingette over the length of the arm, or the fitting of an elastic glove to reduce hand edema, may be done early in the course of treatment to assist in reduction of distal edema.

**Fractures of the Forearm**

**Isolated Ulna Fractures**

Rotation of the human forearm does not allow easy stabilization of forearm fractures with the fracture-bracing technique. Isolated fractures of the distal half of the ulna, however, may be adequately stabilized with a fracture brace, provided the radioulnar joint is intact (Fig. 127-8). Isolated fractures of the distal half of the ulna are inherently stable because the strong interosseous membrane maintains its position in the forearm. Stability is enhanced by molding the brace so it directs pressure through the soft tissues toward the interosseous membrane both dorsally and volarly (Fig. 127-9, online). This is accomplished by firmly molding the thermoplastic material between the radius and the ulna both volarly and dorsally. A cross section of the brace would reveal a slight depression of the material in these areas. This intimate mold provides pressure on the interosseous membrane, creating tautness, and this tautness assists in fracture stabilization. The use of a fracture brace with these isolated fractures is an excellent method of treatment associated with minimal complications.

Circumferential designs that do not accommodate the shape needed for interosseous membrane compression are thought by some authors to contribute to radial deviation of the fracture. These authors have recommended an overlapping prefabricated design. In my experience, a circumferential design made of thin (1/8-inch) orthotic material can be
used successfully (see Fig. 127-8) because the custom molding ensures pressure on the interosseous membrane, even when slight adjustments are made as edema decreases. As with other functional bracing, the isolated ulna fracture is fitted with a functional brace only after the initial pain and swelling have subsided.

A cylinder with overlapping edges is applied to the forearm while in a neutral position. Pressure is maintained on the interosseous membrane dorsally and volarly while the plastic material is hardening. Circumferential hook-and-loop straps with a D-ring closure are applied so the patient may adjust the tightness of the cylinder.

**Double-Bone Forearm Fractures**

Although functional bracing alone cannot control angulation and rotation of forearm fractures, fitting of a functional brace after open reduction and plating can add protection to the healing forearm fractures. When molded along the interosseous membrane, the brace limits supination and pronation, which are the greatest torque forces crossing the fracture. Sarmiento states that some diaphyseal fractures of both bones of the forearm can be functionally braced after 3 weeks of casting.

**Colles’ Fractures**

In an effort to decrease stiffness and rehabilitation time, functional-bracing techniques were applied to Colles’ fractures by Sarmiento and associates in the 1970s and 1980s. The forearm was immobilized in supination, and partial wrist motion was allowed. Studies of this treatment technique did not prove that it prevented collapse. Results of comparison groups showed no final functional differences, although the group receiving functional fracture bracing showed earlier return of functional use.

Functional bracing of Colles’ fractures has not gained wide popularity. The advent of new casting materials and external and internal fixation devices has provided additional treatment options in difficult fractures. Sarmiento currently states that if restoration of length is important, it can best be achieved with surgery and fixation. He believes that only isolated radial fractures without radioulnar disruption can effectively be treated with a functional brace.

**Metacarpal Fractures**

Although the metacarpal bones do not have surrounding muscles that can be compressed circumferentially to provide a stabilizing force, some stable metacarpal fractures can be treated effectively with fracture bracing. With metacarpal fracture bracing, the concept is not one of reducing fracture angulation and displacement as much as it is of protecting the fracture from excessive forces during healing. The major role of fracture bracing of metacarpal fractures is the elimination of bulky immobilization and resumption of normal active motion of distal joints during bone healing.

Isolated fractures of the finger metacarpals without significant shortening or rotation can be stabilized using the adjacent uninjured metacarpals. The intermetacarpal ligaments, which maintain the relationship of the distal end of the metacarpals, prevent excessive displacement of the distal bone fragments. Flexion and extension of the fourth and fifth metacarpals at their bases can be constrained by molding a form that holds the four metacarpals together with the less mobile second and third metacarpals (Fig. 127-10).

In addition to using the adjacent metacarpals for stability, the proximal phalanx may be positioned so that it holds the distal metacarpal fracture fragment and provides stability. Jaliss introduced the concept of controlling metacarpal fractures by arresting the motion of the metacarpophalangeal (MCP) joint. When the MCP joint is flexed to 90 degrees, the collateral ligaments at the MCP joint are maximally tight. Purchase on the proximal phalanx when the MCP joint is fully flexed holds the metacarpal head securely, and when the proximal phalanx is moved, the distal metacarpal fragment moves with it.

The position of MCP joint flexion not only provides some metacarpal fracture stability but also assists in maintaining the length of the collateral ligament at the MCP joint. Flexion of this joint often is hard to regain after prolonged immobilization in extension. MCP joint flexion also puts the intrinsic muscles in a mechanically effective position to pull the interphalangeal (IP) joints into extension, preventing the common complication of proximal interphalangeal (PIP) joint flexion contraction. The position of MCP flexion, however, encourages tightness of the interosseus muscles, making it difficult for the patient to regain full active finger flexion. As soon as it is safe, the patient should be instructed to remove the fracture brace and actively extend the MCP joints as well as gently block them in extension while fully.
actively flexing the IP joints to maintain both interosseous and lumbrical muscle length.

Active flexion of the IP joints while the MCP joints are held in flexion provides a pumping effect for edema reduction and a compression force to the metacarpal fracture (Fig. 127-11, online). This stimulates increased healing but does not produce displacement forces. While bony alignment is maintained in a stable metacarpal fracture, the force of active flexion allows glide of soft tissue across the fracture site. It is the uncontrollable torque forces of resisted motion that provide deforming forces. Fracture bracing is intended to allow anatomic motion and to prevent the introduction of undue external torque forces.

The pull of the interosseous muscles prevents some metacarpal fractures from being stabilized adequately by fracture bracing. Because tolerance to angulation, rotation, or shortening in hand bones is much less than in larger proximal long bones, precise reduction may require internal or external fixation. If more than one metacarpal is fractured, using the adjacent metacarpals to provide stability is difficult. Multiple metacarpal fractures often need surgical stabilization. Fracture bracing for surgically stabilized fractures provides additional protection during early motion and is often employed.

Early motion of fractures of the hand is required if the small joints are to remain mobile and gliding of the surrounding soft tissue structures is to continue. Stable fractures of the hand need little immobilization, and early motion should be encouraged. Wright’s study of early motion with metacarpal and phalangeal fractures showed that 81% of patients had full return of function when there was no immobilization of stable phalangeal fractures.17 The fracture brace decreases pain and provides protection so early active motion is easier to accomplish.

**Metacarpal Shaft Fractures**

Isolated metacarpal shaft fractures often have limited displacement because the shafts of the metacarpals are linked proximally and distally by interosseous ligaments. If angulation occurs, it is with the apex of the fracture dorsally.3 The extensor tendons lie directly on the peristeme of the metacarpals, and fractures immobilized for a long period create extensor tendon adherence to the fracture site. This adherence is a common reason for limited finger motion following fracture healing.

Minimally displaced shaft fractures may be adequately treated with a simple molded shell that holds the four finger metacarpals as a unit but allows full finger motion (see Fig. 127-10). The injured finger is usually buddy-taped to an adjacent finger during active motion to prevent unwanted rotational force, which would be translated proximally to the fracture site. If desired, the proximal phalanx of the involved digit may be included in the brace as a means of adding protection from external forces (Fig. 127-12, online). This is mandatory rather than optional in the young athlete or the manual laborer.

Many advocate the use of an ulnar or radial gutter cast or brace to immobilize metacarpal shaft fractures. Because of the bulkiness of plaster of Paris, it is difficult to mold accurately so that the fracture is secure but full motion is possible in the IP joints. Thermoplastic materials allow precise molding and uninvolved joints are allowed full motion. Complete radiotrascency of the plastic orthotic materials allows easy radiograph follow-up.

The disadvantage of the plastic materials is that their occlusive nature requires the patient to periodically remove the brace for skin hygiene. For this reason, fracture bracing of metacarpal fractures can be used only with stable fractures.

The Galveston brace, a three-point prefabricated brace, was introduced by Viegas and colleagues14 and advocated for treatment of metacarpal shaft fractures. Other reviewers have observed pressure necrosis of the skin over the dorsum of the hand,14,16 and therefore the use of this prefabricated design has not gained wide popularity. Experience with the Galveston brace supports the argument for a custom-molded fracture brace that distributes pressure evenly. An intimately conformed fracture brace stabilizes the fracture by direct pressure over the bone as well as by positioning surrounding tissue for support. Pressure is distributed rather than concentrated.

**Metacarpal Neck Fractures**

Because of the mobility of the fourth and fifth metacarpals at their carpo-metacarpal joints, as much as 20 to 30 degrees of angulation of a metacarpal neck fracture can be accepted and is associated with minimal functional disability. The more stable second and third metacarpals can accommodate only 10 degrees of angulation.13,14,16 Metacarpal neck fractures often require no manipulation and simply need protection as healing occurs. As with metacarpal shaft fractures, flexion of the MCP joint can provide a stabilizing purchase on the distal fracture fragment. The most common neck fracture is seen in the fifth metacarpal, usually resulting from a blow to the metacarpal as the fingers are in full flexion, commonly called a boxer’s fracture. Displaced closed metacarpal neck fractures should be treated by closed means and often require no reduction.28 Since there is no statistical difference in fractures treated with a variety of treatment approaches, a short period of immobilization and protection is the standard treatment.

A fracture brace for fourth or fifth metacarpal neck fractures uses the same principles and design as for metacarpal shaft fractures. The four finger metacarpals are encompassed in a molded brace to prevent flexion and extension of the fourth and fifth metacarpals at their bases. The proximal phalanx of the digit with the fractured metacarpal is held with the MCP joint in flexion (Fig. 127-12, online) and often includes the MCP joint(s) of adjacent fingers (Fig. 127-13, online). Full flexion and extension of the IP joints is encouraged within the brace. The patient must remove the brace for skin hygiene and is encouraged to move the MCP joints actively when out of the brace for brief periods.

The fracture brace for metacarpal neck fractures of the second or third metacarpals uses the same principle of MCP joint flexion. The brace need not stabilize the mobile fourth and fifth metacarpals. Thus a radial design may be used (see design of Fig. 127-14).

If the brace is fitted acutely when edema surrounds the fracture site, full MCP joint flexion may be impossible.
short period of immobilization in a bulky dressing to reduce edema may be indicated before fitting the brace. One may easily remodel a previously fitted thermoplastic brace to accommodate decreased edema and accomplish greater MCP joint flexion. The patient may be instructed to wear double layers of stockinette or a piece of a thicker athletic sock to fill the space created by the edema reduction until return for remodeling. In some cases, the thicker sock may be adequate for the duration of treatment.

Proximal Phalanx Fractures

Closed stable proximal phalanx fractures can be treated successfully with early motion and functional bracing. This technique is most effective with dorsally angulated, transverse shaft, or short oblique shaft fractures. A stable impacted base fracture that has been reduced is also suitable. Burkhalter and Reyes introduced the concept of functional casting for phalangeal fractures using the same principles of soft tissue support for fracture stability (see Fig. 127-11, online). MCP joint flexion puts tension on the dorsal hood epaxial over the proximal phalanx, providing a taut dorsal constraint that minimizes dorsal angulation of a proximal phalanx fracture. Active finger flexion in this protected position provides appropriate compressive forces that stimulate healing. Digital rotation and angulation are controlled by moving all four digits together. The proximal phalanx does not enjoy the stabilizing force of adjacent bones as does the metacarpal, but the dorsal hood tension caused by the flexed MCP joint can stabilize selected fractures.

The most common problem with closed reduction and casting of these fractures is the difficulty in securing MCP joint flexion to maintain reduction while also ensuring room for full IP joint flexion.

Fractures of the Base of the Proximal Phalanx

Fractures of the base of the proximal phalanx generally are inherently stable because of the wide bony contact and the impaction often seen in these fractures. The proximity of these fractures to the MCP joint creates concern about the need for early MCP joint flexion. Stable proximal phalanx fractures may be adequately protected with a fracture brace that encompasses the metacarpals and the proximal phalanx of all injured digits (see Fig. 127-13, online). Glide of tendons across the fracture site continues, and external torque forces are minimized. As with metacarpal neck fractures, the patient can safely remove the protective brace to bathe the hand and to actively flex and extend the MCP joints.

In injuries creating multiple proximal phalangeal fractures, the ability to begin early motion has multiple advantages. The pumping effect of early motion minimizes edema within the finger and the hand since only the MCP joints are constrained. The gentle stress of the controlled active motion stimulates bone healing. Perhaps the biggest advantage of the fracture-bracing technique for this injury is the ability to maintain glide of the dorsal hood mechanism across the fracture site to preserve full IP joint motion.

Midshaft Proximal Phalanx Fractures

Midshaft proximal phalanx fractures angulate with the apex dorsally because of the pull of the flexor tendons, which insert distal to the fracture. The taut dorsal hood, as described by Burkhalter and Reyes, reduces this angulation while allowing the hood to glide across the fracture site, preventing adherence (see Fig. 127-11, online). Flexion of the MCP joint also puts the interosseous and lumbrical muscles in an optimal position to accomplish full IP joint extension.

Not only does a fracture brace stabilize the fracture while allowing full IP joint motion, but a removable piece of orthotic material can support the IP joints in extension when they are at rest, thereby preventing the frequent complication of a proximal IP joint flexion contracture (Fig. 127-14D).
Summary

Whether fracture bracing is used for the humerus and forearm or for selected metacarpal and proximal phalanx fractures, soft tissue provides the stabilizing forces. Stability of long-bone fractures can be accomplished because of the constrained bulky muscles surrounding the fracture, which exert an effective stabilizing force. Fracture bracing of the metacarpals and proximal phalanges must be used more selectively because of the functional intolerance of the hand to bony rotation, shortening, or angulation.

Regardless of the anatomic application of this technique, the advantages of early reduction of edema, maintenance of gliding of surrounding soft tissues, and early functional use make this an attractive and useful technique for cooperative patients.

REFERENCES

The complete reference list is available online at www.expertconsult.com.
References