Fractures of the Proximal Fifth Metatarsal: Selecting the Best Treatment Option

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Abstract

Because of circulatory differences in the three zones of the proximal fifth metatarsal, the location of a fracture must be considered when selecting treatment. The most proximal portion of the base of the fifth metatarsal has good blood supply. Fractures in this zone usually extend into the fifth metatarsocuboid joint. The second zone is associated with Sir Robert Jones, who in 1902 first asserted that fractures of the fifth metatarsal are commonly caused by indirect violence. Fractures in this zone take longer to heal than more proximal fractures, and treatment should be individualized. Whether to use a functional metatarsal brace, a stiff-soled shoe, a short-leg cast, or even internal fixation with a screw depends on the patient's lifestyle and desired activity level. Fractures in the third zone occur between the distalmost portion of the metaphysis and the proximal 1.5 cm of the diaphyseal tubular bone. This zone begins just distal to the ligamentous complex holding the proximal fourth and fifth metatarsals together. In active athletes, fractures in this zone often are stress injuries. For anatomic and mechanical reasons, such fractures are the most difficult to heal. Without surgical treatment, they may take 2 to 21 months to unite and are therefore more likely to need aggressive treatment.

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Confusion exists in the medical literature regarding fractures of the proximal fifth metatarsal. This confusion exists largely because of differences in nomenclature,[1-5] subtle variations in bone structure, and the multiplicity of external forces that can cause injuries in the three distinct anatomic zones of the proximal end of this unique bone.

In this article I will describe those anatomic zones and the clinical importance of the blood supply to each zone. I will also review the contributions of Sir Robert Jones to our knowledge about such injuries, as well as the current consensus on mechanisms of injury, treatment indications, and techniques of treatment.

Anatomy

Clinical Zones

The proximal fifth metatarsal has been classified into three zones[1,4-7] (Fig. 1). Zone 1, the most proximal zone, is the cancellous tuberosity. It includes the insertion of the peroneus brevis tendon and the calcaneometatarsal ligamentous branch of the plantar fascia. Zone 1 fractures usually extend into the fifth metatarsocuboid joint.

Zone 2 includes the more distal tuberosity. Fractures of this zone extend into the area of articulation of the fifth metatarsal with the fourth metatarsal. This middle zone shares some characteristics with zones 1 and 3. The ligaments holding the fourth and fifth metatarsals together proximally are quite secure on both the dorsal and plantar aspects of zone 2.

Zone 3 begins just distal to these ligamentous structures and extends distally into the tubular portion of the diaphysis for approximately 1.5 cm.

The three anatomic zones coincide very well with the clinical differences in fractures of the proximal fifth metatarsal.[1,4,6] However, variations in the size and shape of the proximal fifth metatarsal and its articulations may make it difficult to define exactly the borders of each individual zone; there may be a difference of a few millimeters in the borders of the zones in different feet.

Blood Supply

Several publications have illustrated the importance of the blood supply of the fifth metatarsal with regard to fracture healing.[3,5-8] Just as there may be slight differences between individuals in the location of the anatomic zones, so may there be slight variances in the contour of the blood vessels. In general, however,

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the nutrient artery to the fifth metatarsal enters medially in the middle third of the bone (Fig. 1). It courses slightly proximally through the medial cortex and quickly divides into a distal branch and a shorter proximal branch. There is an abundance of very small metaphyseal vessels at each end of the bone. Injuries to the proximal diaphysis of the metatarsal are likely to injure the proximal branch of the intraosseous nutrient vessel and to impair the blood supply to the distal portion of the proximal fragment of the bone.

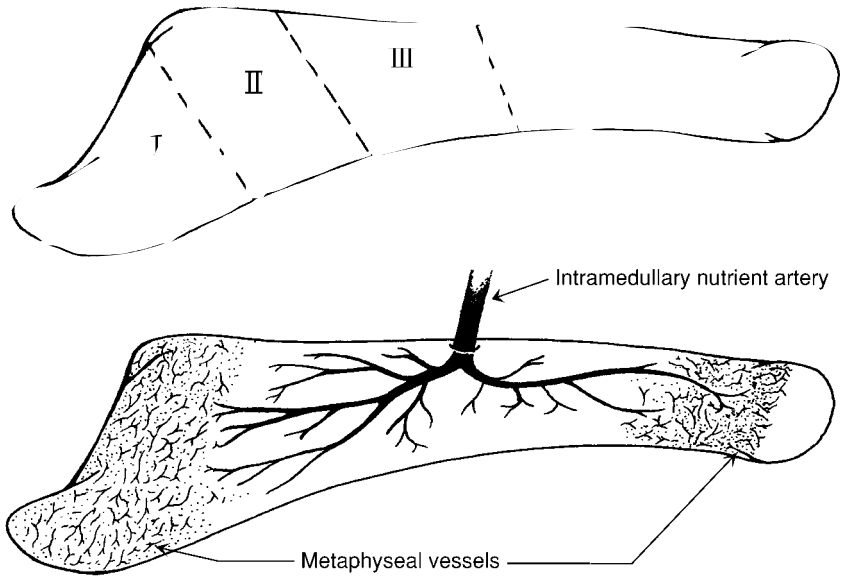

Fig. 1 **Top,** The three anatomic zones at the base of the fifth metatarsal: zone 1 includes the articular surface of the fifth metatarsocuboid joint; zone 2 encompasses the articulation of the proximal fourth and fifth metatarsals; zone 3 extends 1.5 cm distal to zone 2. **Bottom,** The arterial blood supply of the fifth metatarsal. The intramedullary nutrient vessel enters the medial aspect of the fifth metatarsal in the middle third of the bone. It divides into shorter proximal and longer distal branches. There are multiple minute vessels in both the proximal and distal metaphyses. There is little collateral circulation to the nutrient vessel at the junction of the diaphysis and the metaphysis proximally.

The Contributions of Sir Robert Jones

Sir Robert Jones published his classic article "Fracture of the Base of the Fifth Metatarsal Bone by Indirect Violence" in *Annals of Surgery* in 1902.[2] His interest was initiated by a foot injury he incurred while dancing. He disagreed with the then-universal opinion that all metatarsal fractures are due to direct violence and reported six cases that had all occurred without direct violence.[2,4] In his article, he included full-page reproductions of the x-ray images in each of the six cases. Because these images were made in the early days of radiography, it is difficult to determine the exact course of most of the fracture lines; Jones himself noted that "all the lines of the fracture cannot be traced quite through the bone but there is little doubt that the fracture is complete."

Case 1 in Jones's series is his own metatarsal fracture. The published radiograph shows a definite but fine fracture line extending through the lateral cortex in the direction of the proximal portion of the articulation between the fourth and fifth metatarsals. Jones described well the usual mechanism of his injury (a zone 2 fracture).[9] He stated, "A fracture occurs therefore exactly where one would expect it to occur and where our skiagrams illustrate. So powerful are these ligaments that dislocation of the base is the rarest of accidents. It is obviously easier to break the bone than to dislocate it." He noted further, "When the heel . . . is off the ground, body weight expends itself upon the fifth metatarsal, rotating [adducting] it slightly inward. The opposition to this force takes place where the strongly attached ligaments resist its displacement."[1,2]

Jones's recognition that fractures of the base of the fifth metatarsal can occur without direct trauma was very important, and naming this fracture for him is a well-deserved recognition,[10] although it is now appropriate to use his name only when referring to fractures in zone 2.

Also included in Jones's report is a case of a more distal fracture (Fig. 2). The fracture line is much clearer than in his other cases. The radiograph shows that the cortex of the proximal fragment has thickened and the intramedullary canal displays sclerotic changes and narrowing on each side of the fracture.

Since Jones's report it has become generally appreciated that fifth metatarsal fractures in zone 3 are usually, but not always, stress fractures. As Jones pointed out, the strong and complex ligamentous structures joining the fifth metatarsal to the fourth metatarsal prevent dislocation. However, such rigid fixation at the proximal end of the fifth metatarsal transfers the bending forces applied to the distal metatarsal to the base of the tubular portion of the bone. Stress from the lateral aspect of the fifth metatarsal head occurs in zone 3, where repeated

Fig. 2 Case 2 from Sir Robert Jones's series.[2] The fracture line is more distal than in Jones's own injury. There is intramedullary sclerosis on each side of the fracture line and some periosteal new-bone formation on the proximal fragment at the fracture line. These changes are characteristic of stress fractures of the base of the fifth metatarsal.

varus forces on the distal end of the bone are thought to cause stress fractures.[5,9,11] Radiographically, these fractures are usually seen to open up laterally, not inferiorly, suggesting that the origination of the force vector is more lateral than plantar.

Mechanisms of Injury and Treatment Indications

Zone 1 Fractures

Fractures in zone 1 usually begin laterally on the tuberosity and extend proximally into the metatarsocuboid joint. They course through the cancellous bone, which has an excellent blood supply. They are most often traction (avulsion)-type injuries from forces exerted at the insertion of the peroneus brevis tendon and/or the lateral cord of the plantar aponeurosis.[3] There has been very little difficulty reported in obtaining successful healing of these fractures.[4,12-15] The consensus is to treat them symptomatically with weight-bearing as tolerated.[4,15,16] The patient can be made more comfortable by applying an elastic wrap or a functional brace and using a wooden-soled postoperative shoe. A short-leg walking cast or brace may be useful to improve comfort and mobility. The type of treatment does not appear to have any direct correlation with the length of time necessary for the symptoms to subside. Radiographic evidence of union becomes apparent more slowly than pain resolution and is the much more important consideration in treating these fractures. A radiographic appearance suggestive of delayed union or nonunion in this zone is rarely associated with symptoms.

Seldom is operative treatment of zone 1 injuries necessary. Rarely, an active young person with an unusually long tuberosity will have significant displacement (3 mm or more) of the proximal fragment and significant rotary displacement, which requires operative reduction and internal fixation,[9,13,14,16] preferably with a mini-screw or small Kirschner wires.

Zone 2 Fractures

Zone 2 fractures begin laterally in the more distal portion of the tuberosity. They extend obliquely and proximally from the lateral cortex into the area of the medial cortex where the fifth metatarsal articulates with the fourth metatarsal. This type of fracture is apparently similar to three of the six cases reported by Jones,[2] including his own injury. Compared with zone 1 fractures, these injuries are usually more painful and often require more aggressive treatment, such as use of a short-leg cast or a functional metatarsal brace. Internal fixation may be indicated in patients with high-demand activities. These fractures take much longer to heal when they are not at least partially protected.

Zone 2 fractures often are moderately comminuted with extension into the metatarsocuboid joint and the intermetatarsal articulation. Treatment of such injuries must be individualized. A functional metatarsal brace or a short-leg cast will usually allow comfortable walking and shorten the bone healing time. There are differences of opinion regarding the efficacy of not bearing weight when in a cast.[4,14-17] These fractures may continue to be mildly or moderately symptomatic for several months, particularly if the injured person continues repetitive stressful activities, such as running. Internal fixation with a compression screw may be considered if a patient is eager to return to an active exercise program. Surgery usually significantly shortens the healing time and allows athletic patients to return to their sports activities much more quickly. However, to avoid refracture they should continue to use a functional metatarsal brace for at least 1 month after surgery.[11,15]

Zone 3 Fractures

Zone 3 fractures generally take longer to heal than other fractures of the forefoot. They are similar to case 2 in Jones's series (Fig. 2) and occur distal to the area where the strong ligaments bind the fourth and fifth metatarsals together.

Fractures in zone 3 most often are stress fractures. These injuries usually occur in persons who are involved in competitive athletics, particularly in running sports and sports that require making sharp turns on a firm surface while running, such as basketball. These fractures are often quite slow to heal, particularly when the patient continues even moderate athletic activities.[1,4,5,11,14-16,18]

Stress fractures often are symptomatic for several days before the fracture line becomes demonstrable radiographically. It is not unusual for persons involved in competitive athletic activities, such as basketball, track, and football, to have been treated for "tendinitis" for 2 or 3 weeks before a radiograph showed the fracture. During this time, the stress fracture can often be identified on an x-ray film by the presence of a small area of periosteal new-bone buildup at the point of maximum tenderness on the lateral aspect of the metatarsal, or it can be diagnosed earlier on a technetium bone scan. When discovered early, fifth metatarsal stress fractures usually can be treated successfully without surgery by means of modification of activity and the use of a functional metatarsal brace. If the fracture becomes complete in an individual with a compelling reason for early return to athletics, this would be a relative indication for surgery.

Relative Frequency in Author's Experience

To gain a better perspective on the frequency and outcome of treatment of fractures of the base of the fifth metatarsal, we reviewed the records of patients with such injuries who were treated in our general orthopaedic practice during the 5 years from 1988 through 1992 (unpublished data, 1994). Of 237 patients, 91 (38%) were male and 146 (62%) were female. In younger patients, there was a male predominance; however, after age 30, fractures occurred more frequently in women. Of the 237 fractures, 221 (93%) were in zone 1, 9 (4%) were in zone 2, and 7 (3%) were in zone 3.

Only 4 patients underwent surgery; an intramedullary compression screw was used in each case. One patient had a zone 1 injury in which the tubercle had pulled off, displaced, and rotated at the insertion of the peroneus brevis. Thus, only 1 patient of the 237 had as much as 2 mm of displacement of a fracture and that fracture was due to indirect violence.

Treatment

Metatarsal Functional Bracing

In 1983, Reibel and Colditz developed a functional fifth metatarsal brace by molding a 1/8-inch-thick low-temperature thermoplastic material directly over all metatarsals, with an opening on the medial side of the foot (Fig. 3). The curved shape of the mold around the fifth metatarsal strengthens the brace and prevents movement of the metatarsals while withstanding forces of ambulation and play. The brace has no straps but is held securely by wearing a firmly laced tennis shoe over it.

In our practice, the application of this brace has been effective in treating acute fractures after a short period of immobilization and elevation for edema reduction. It is used in any patient with a zone 1 or zone 2 fracture or in a low-activity patient with a zone 3 fracture. The patient's increased comfort during ambulation after application of this brace is dramatic, often allowing immediate abandonment of crutches.

Surgical Technique

Fractures in zone 3 and the distal portion of zone 2 may require operative treatment to allow earlier resumption of the patient's desired lifestyle. The preferred treatment at this time is internal fixation with a compression screw.[4,11] The surgery is carried out with the patient turned 45 degrees onto the uninjured side on the operating table, exposing the lateral side of the foot. A 3-cm dorsolateral incision is made over the tuberosity of the fifth metatarsal and is continued proximally over the distalmost fibers of the peroneus brevis tendon, which is retracted inferiorly. A Kirschner wire or small drill is inserted into the proximal tip of the metatarsal. Fluoroscopy can be help-

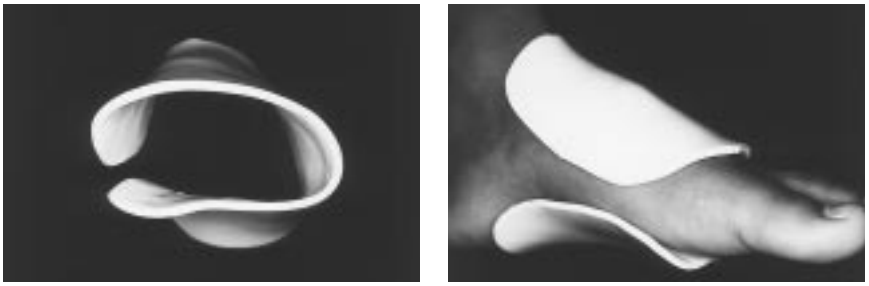

Fig. 3 **A**, Anteroposterior view of a functional brace for proximal fifth metatarsal fractures. The brace gains purchase on the metatarsals (including the fifth metatarsal head) distally, allowing full metatarsophalangeal motion in all toes. **B**, Medial view of functional brace in place.

ful in confirming the position and determining the screw length. A cancellous lag screw is inserted (a 4.5-mm screw is usually preferred in an average-sized person), taking care that the screw threads are well distal to the fracture.

In our earlier experience, we used a small rectangular bone graft from the tuberosity.[15,16] The graft would then be turned 180 degrees, so that the fracture line on the graft would be away from the fracture line in the host bone. We have since found that fractures heal more quickly with the use of a compression screw. The fine bits of bone obtained with the drill in preparation for the screw are used under the conservatively and carefully elevated periosteum at the fracture site as a graft. The foot is kept nonweight-bearing until the skin incision has healed. A short-leg walking cast is then used for a total of 4 to 6 weeks after surgery, depending on the patient's size and activity demands. A functional brace is worn for an additional 4 weeks (longer if the patient is engaging in strenuous competitive sports).

Summary

Both the anatomic features and the response to injury of the proximal fifth metatarsal correspond to three distinct and meaningful zones. In zone 1, the fractures occur through the proximal tuberosity, with the fracture line usually beginning at the lateral cortex and extending medially into the metatarsocuboid joint. These are usually avulsion-type injuries, which can effectively be treated symptomatically with an elastic bandage, a stiff-soled shoe, or a functional brace. Persons with this injury can usually resume activity as their symptoms allow and need not wait for radiographic evidence of bone union.

Zone 2 (Jones) fractures extend from the lateral cortex into the area of articulation of the fifth metatarsal with the fourth metatarsal. They usually occur when the foot is plantar-flexed and sustains significant adduction force on the distal metatarsals. These fractures heal more slowly than the more proximal tuberosity fractures but do not usually take as long to heal as zone 3 fractures. Zone 2 fractures are prone to refracture if repetitive stress is applied to the injury before there is radiographic evidence of mature bone union. A short-leg cast is recommended for up to 6 weeks, after which time a functional brace is used. Early weight-bearing is controversial, but no deleterious effect has been proved.[4,15,17,18]

Zone 3 fractures occur just distal to the ligamentous structures that bind the proximal fourth and fifth metatarsals. They most frequently occur during running sports activities and are usually stress fractures. If untreated, zone 3 fractures cause discomfort, which is accentuated by physical activities (which also prolong the healing time). Limited walking activities with a stiff-soled shoe or a functional brace for a few months may be used to treat these fractures in moderately sedentary persons. Using a short-leg cast may shorten the healing time, but not nearly as much as internal fixation with a compression screw. If activity is not reduced, healing time for zone 3 fractures may be prolonged to over 2 years. Although these injuries are prone to prolonged healing time, true pseudarthroses seldom, if ever, occur.

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