CHAPTER **28**

TREATMENT OF FIFTH METATARSAL FRACTURES: Guidelines for Decision-Making

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INTRODUCTION

Fractures of the fifth metatarsal present a unique set of challenges for treatment to the foot and ankle specialist. Understanding the local anatomy, vascular supply, function, and dynamic stresses placed upon the bone, as well as fracture classifications, mechanisms of injury, and expected responses to treatment aid immensely in the decision-making processes. The author will briefly summarize the large amount of literature that has been generated on this unique topic and leave the reader with a succinct set of guidelines for treatment.

EPIDEMIOLOGY

Metatarsal fractures are among the most common injuries to the foot. They are roughly 10 times the frequency of LisFranc's fracture-dislocations. Specifically, in 2 reviews, of 10,988 foot fractures, the proximal fifth metatarsal diaphyseal-metaphyseal Jones fracture (acute and stress) had a frequency of 0.7%-1.9%.[1,2] In children, 61% of all foot fractures involve the metatarsal bones and most (41%) are of the fifth ray. In a study of industrial injuries, the fifth metatarsal - including base fractures - was the most commonly fractured at 23% followed by the third metatarsal. Stress fractures, which are seen especially in military, athletic and dancer populations, most commonly affect the second, third and fifth metatarsals at their proximal third.[3]

Fractures of the base of the fifth metatarsal are more common than distal fractures of the shaft or head and neck. The proximal fifth metatarsal has been divided into 3 zones. In one study of 237 patients with fractures of the proximal fifth metatarsal, 62% were female and 38% were male. The most common proximal acute disruption was tuberosity (zone I) fractures (93%) in this general orthopedic population.[4] The incidence of true acute Jones (zone II) fractures was found to be higher in the military population (25%).[5] Fractures in the more distal zone III close to the diaphysis were most commonly stress-induced fractures.

ANATOMY AND DYNAMICS

The fifth metatarsal is a long bone consisting of a head, neck, shaft, base and tuberosity or styloid process. The metaphyseal base tapers distally to the more tubular diaphysis which, besides being more convex dorsally, is actually wider in cross-section from medial to lateral than it is from dorsal to plantar. Also, the diaphyseal cortices tend to be thinner on the dorsal and plantar sides than on the medial and lateral sides. The bone often bows laterally.[6] These are significant considerations when planning intramedullary screw placement. The tuberosity protrudes laterally and plantarward from the base.[7]

Proximal articulations of the fifth metatarsal are with the cuboid bone and adjacent base of the fourth metatarsal. Sturdy ligaments both dorsally and plantarly connect the cuboid to the base of the fifth metatarsal as well as to the base of the fourth metatarsal. The 2 adjacent bases are also connected by ligaments. The long plantar ligament extends from the distal calcaneous across the cuboid and inserts into the base of the fifth metatarsal, while more superficially, the lateral band of the plantar fascia sends a slip into the plantar tuberosity. It has been suggested to be more responsible for tuberosity fractures than the more prominent dorsal insertion of the peroneus brevis tendon into the tuberosity.[8,9] The insertion of the peroneus tertius tendon more distally onto the drorsal base of the fifth metatarsal is thought to have minimal influence as a fracture force.

There are 3 main muscle slips that arise from the fifth metatarsal: the flexor digiti minimi brevis from the plantar base and the dorsal and plantar interossei from the medial surface with only the dorsal interossei opposed by its counterpart attached to the fourth metatarsal. Occasional variations from the normal muscle anatomy include: part of the abductor digiti minimi muscle can originate from the plantar aspect of the fifth metatarsal base; if present, the abductor ossi metatarsi quinti muscle inserts into the styloid process; and, when present, the opponens digiti minimi muscle inserts into the lateral border of the fifth metatarsal shaft.[10]

Biomechanically, the fifth metatarsal functions with an independent axis of motion that allows primarily dorsiflexion and plantarflexion with inversion-eversion as potential movements as well. Strong soft tissue attachments that contain the base stabilize it against acute and repetitive force attacks. Excessive acute and repetitive strain loads on the bone are usually flexural, whereas torque can occur with inversion injuries.

Two studies have investigated the vascular supply to the fifth metatarsal.[11,12] The tuberosity is well supplied by from numerous random vessels that are directed from the metaphysis. There is a nutrient artery supplying the diaphysis but the proximal diaphyseal region contains a watershed "no man's land" where there is a run-out of the nutrient artery before the metaphyseal vessels are encountered. This area of poor vascular supply is thought to be the etiology of delayed union or nonunion of fractures in this area, especially if the nutrient artery is disrupted.[13]

There are anatomic variations that may result in confusion with fractures of the tuberosity of the fifth metatarsal. The os peroneum, within the peroneus longus tendon, is usually situated lateral to the cuboid bone whereas the os vesalianum within the peroneus brevis tendon sits adjacent to its insertion. Also, the apophysis, or growth center may be confused with a nondisplaced tuberosity fracture in a child. The apophysis can be identified by means of a smooth, radiolucent line running parallel to the metatarsal shaft. This growth center first appears in males between ages 9-11 years and in females from 11-14 years. The line obliterates by fusing with the tubersity 2-3 years after its appearance.[14,15] When the apophysis is afflicted with osteochodrosis it is known as Iselin's disease; its pain and tenderness may mimic a tuberosity fracture.[16-18]

Figure 1. Diaphyseal stress fracture in a 64-year-old diabetic female with metatarsus adductus and Charcot neuroarthropathy.

MECHANISM OF INJURY

Foot plantarflexion with an adduction force applied to the forefoot is the source of most acute injuries to the base of the fifth metatarsal whether it causes a tuberosity fracture or Jones fracture or even a cervical fracture. Hence, these injuries are often encountered in such sports as basketball, football, soccer and tennis as well as dancing and gymnastics. They are also seen in the general population as the result of sudden inversion injuries such as slipping while going down stairs or stepping over an edge. The locking configuration of all the soft tissue constraints about the base make dislocation of the fifth metatarsal-cuboid joint an exceedingly rare occurrence.

Stress fractures, which usually disrupt the proximal diaphysis, are the result of repeated submaximal distraction forces. One biomechanical study revealed that the peak stress point occurs approximately 3.38 to 4.05 centimeters distal to the tuberosity when the load is directed 30 to 60 degrees from the horizontal plane relative to the long axis of the metatarsal.[13] Structural and bio-mechanical abnormalities can contribute to the production of these repetitive load concentrations. Examples include uncompensated forefoot varus,[19] rigid pes cavus, metatarsus adductus,[20] talipes equinovarus,[21] post Evan's calcaneal osteotomy,[22] Charcot foot,[23,24] and Charcot-Marie-Tooth disease.[25] (Figure 1) Dancers, distance runners and military trainees are especially subject to fifth metatarsal stress fractures at the base or proximal diaphysis although stress fractures of the second metatarsal are more common.[13,16,26,27]

CLASSIFICATION

Quill presented a useful classification for fracture patterns that occur in the proximal fifth metatarsal.[28] He divided the fractures in this region of the bone into 3 areas, sometimes referred to as zones[4]: tuberosity avulsion fractures (Zone I), Jones fractures (Zone II) and proximal diaphyseal stress fractures (Zone III). (Figure) Vogler added three other locations in his anatomic classification to better define treatment options for the various fractures of the complete fifth metatarsal: capitum fractures, cervical fractures and shaft fractures (Table 1).[29]

Each of the fracture patterns has its own unique location, mechanism of injury, treatment options, and prognosis regarding delayed union and nonunion.

Torg further subdivided the proximal diaphyseal stress fractures, also applicable to Jones fractures, into three subtypes based on their radiographic signs of healing: type I - acute or early union characterized by a narrow fracture line and absence of intramedullary sclerosis; type II - delayed union, involving fractures with widening of the fracture line and evidence of intramedullary sclerosis; and type III - nonunion, which includes fractures with complete sclerotic obliteration of the intramedullary canal (Table 2).[30]

There has been considerable confusion regarding the exact definition of the "Jones fracture." Jones suffered the fracture himself in 1902 while dancing around a tent pole and recognized it as the result of an indirect force.[31] Stewart defined the true Jones fracture as a transverse fracture at the junction of the proximal diaphysis and metaphysis without extension distal to the fourth-fifth intermetatarsal articulation (Figure 2).[32] It is therefore, an intraarticular fracture into the base fourth-fifth metatarsal facet, often with medial comminution. The diagnosis should not be applied for fractures that extend into the

Figure 2. True acute Jones fracture in a 50-year-old female patient with multiple sclerosis.

Table 1

ANATOMIC DESCRIPTION OF FIFTH METATARSAL FRACTURES*

Tuberosity Fracture
Involves tuberosity or styloid process ("tennis fracture").

Jones Fracture
Area in the junction of the diaphysis and metaphysis, usually involving the fourth and fifth intermetatarsal articular facet.

Diaphyseal Stress Fracture
Pathologic fracture of the proximal 1.5 cm of the fifth metatarsal shaft or diaphysis.

Segmental Shaft Fracture
Fracture of the diaphysis distal to the stress fracture area but proximal to the distal metaphysic and head.

Cervical Fracture
Oblique or transverse fracture in the distal metaphysis usually within 1.5 cm of the metatarsal head.

Capitum Fracture
Fracture of the head of the fifth metatarsal, usually impaction ("tulip fracture").

*Adapted from references 5 and 33

Table 2

TORG'S CLASSIFICATION OF PROXIMAL FIFTH METATARSAL FRACTURES BASED ON RADIOGRAPHIC APPEARANCE*

Type I, Early Union
No intramedullary sclerosis
Fracture line with sharp margins and no widening
Minimal cortical hypertrophy
Minimal evidence of periosteal reaction to chronic stress

Type II, Delayed Union
Fracture line that involves both cortices with associated periosteal bone union
Widened fracture line with adjacent radiolucency related to bone resorption
Evidence of intramedullary sclerosis

Type III, Nonunion
Wide fracture line
Periosteal new bone and radiolucency
Complete obliteration of the intramedullary canal at the fracture site by sclerotic bone

*Adapted from: Strayer SM, Reece SG, Petrizzi NJ: Fractures of the proximal fifth metatarsal. Am Fam Phys, 59:2516-2522,1999.

metatarsocuboid articulation as those are tuberosity fractures. Also, a Jones fracture is an acute injury with no history of prodromal symptoms.[15] It is best seen with a medial oblique radiograph of the foot.

TREATMENT

Surgical Versus Nonsurgical

There has been tremendous debate in the literature regarding whether to treat proximal fifth metatarsal fractures conservatively or surgically. Other than the fractures within zone of relative avascularity, most will heal eventually with immobilization or protected weight-bearing, especially the tuberosity fractures.[5,33] So, if time for return to active function is not critical, conservative management is effective. For performance athletes, delayed union zone fractures and displaced or intraarticular fractures, surgery may be an important consideration.[34]

Tuberosity Fracture (Zone I)

This avulsion fracture ("tennis fracture") almost always heals with nonsurgical management when non-displaced. A hard-soled shoe or walking cast will usually result in relief of symptoms at 3-4 weeks with signs of radiographic union present by 8 weeks.[5,29,22,25] However, the use of a soft Jones dressing has been shown to reduce healing times to an average of 33 days.[35] Functional braces work well also.[4]

Figure 3. Surgical intervention for small tuberosity fracture in a 63-year-old man by fragment excision and re-insertion of peroneus brevis tendon with bone anchors.

For small displaced tuberosity fractures fragment excision and tendon re-attachment may be the best approach. Larger displaced fractures or intraarticular fractures that are displaced with a step-off defect or include over 30% of the width of the fifth metatarsal-cuboid joint are best surgically reduced and fixed. Methods to choose from are tension band, tension band and pins, screws and hook plate technique. When used, screws are best placed bicortical and at right angles to the fracture line (Figure 3).[3,37-41]

Acute Jones Fracture (Zone II)

The true Jones fracture can be treated with a non-weight-bearing cast for 6-8 weeks. For high-performance athletes or patients who demand a rapid return to function, rigid fixation may be applied. The intraamedullary screw has proven to be the more efficient method of fixation, although there are other acceptable methods including tension band wiring techniques.[6,35,42-51] Screw sizes range from 4.0 to 6.5, depending on local anatomy, and cannulated may also be considered.[24] The technique for insertion is best described by DeLee,[42] Nunley,[35] and Lehman (Figure 4).[43] Delayed and non-unions of these fractures can be typed and treated much the same as those in the diaphyseal stress fractures zone.

Diaphyseal Stress Fractures (Zone III)

Stress fractures through zone III where blood supply is limited are best treated according to radiographic appearance of healing. Non-displaced type I fractures can be treated with non-weight-bearing cast immobilization and expect healing at about 7 weeks up to 93% of the time.[30,52] Type II fractures can be casted but take much longer to heal (up to 20 weeks) and still may not unite. Internal fixation has been shown to result in faster healing. Intramedullary screw achieves faster healing than inlay corticocancellous bone grafting.[30,53] The principles for screw fixation technique are the same as for the Jones acute fracture. Type III fractures require internal fixation and bone grafting; healing may be assisted by electrical or ultrasound bone growth stimulators which can be utilized with or without surgical intervention (Figure 5).[50,54]

Shaft Fractures

Pure diaphyseal or shaft fractures are usually oblique. Casting is indicated if they are non-displaced, otherwise K-wire tansfixation or interfragmentary screws can be implemented. Transverse or comminuted fractures that are less stable may require plate or external fixation (Figure 6).[29]

Figure 4A. Preop. Acute Jones fracture in 26-year-old female construction worker, successfully treated with intramedullary screw fixation.

Figure 4B. Postop healed at 8 weeks.

Figure 5. Typical diaphyseal stress fracture full nonunion. Notice its location distal to the fourth-fifth metatarsal base articulation.

Figure 6. Diaphyseal or shaft fracture.

Figure 7. Cervical fracture of the fifth metatarsal.

Figure 8. Capitum or "tulip" impaction facture involving the fifth metatarsal head.

Cervical Fractures

This fracture can present as impaction, transverse, or spiral "dancer's fracture."[55] It can be treated by closed reduction with traction under local anesthesia followed by casting and usually heals well. Fixation may be considered for failure to reduce, dorsal displacement, or spiral shearing (Figure 7).[3,29]

Capitum Fractures

Fractures of the head of the fifth metatarsal are often caused by distal impaction ("tulip fracture") or direct vertical impact. They usually heal well with protected weightbearing. Severe comminution may require head resection (Figure 8).[29]

COMPLICATIONS

The most difficult complications in treating proximal fifth metatarsal fractures are delayed or non-union. When either occurs, treatment choices include ultrasound or electrical bone growth stimulation[50,54,56,57] or surgical repair with autogenous or prepared bone graft. Refracture can occur after return to activity or when the screw fixation has been removed, especially in athletes.[58] Screw fractures, screws missing the intramedullary canal, fracture malalignment, and pain over the prominent screw head have all been reported as complications.[42,59,60]

One of the most frustrating complications of surgery on the base of the fifth metatarsal occurs when there is inadvertent damage to the sural nerve. Since the nerve courses and branches at the tuberosity, it is a structure usually encountered during dissection. Knowledge of its usual expected location and careful atraumatic technique helps avoid such complications and the need for further surgery to release and decompress the nerve.[61,62]

CONCLUSION

The true Jones fracture is a very specific and defined subtype of fifth metatarsal base fractures. Evaluation and treatment of fifth metatarsal fractures in general are best accomplished by dividing the long bone into anatomic regions, each with its own characteristics. Treatment can range from completely nonoperative care for all types of these fractures seen in a general orthopaedic practice[33,63] to surgical repair for all Jones fractures in elite athletes.[64] This paper provides information to help in the decision-making for all other situations involving fifth metatarsal fractures.

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