METATARSAL FRACTURES

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As with many common disorders of the foot, the area of metatarsal fractures has received only superficial attention in historic and current medical and surgical discussions. General principles of fracture management have been sparingly applied to the topic in in most orthopedic and podiatric texts. The fifth metatarsal, however, has received some degree of attention under the eponym of the Jones' fracture and the often mislabeled but very common avulsion fractures of the fifth metatarsal base. Most references dealing with the subject are interesting personal experiences with metatarsal fractures and an attempt to introduce a new or revisited technique for the management of a unique or bizarre injury. Figura presents a logical and rather complete classification of metatarsal fractures and discusses treatment (1).

State of the art has yet to be described in the management of metatarsal fractures. However, the tools are available for a more consistent and definitive course of treatment.

Diagnosis and treatment of metatarsal fracturs is dependent upon:

1. a comprehensive knowledge of metatarsal fractures,
2. thorough clinical and radiographic evaluation, and
3. a sound working knowledge of the principles of treatment including:
   - closed reduction techniques
   - bone healing
   - internal fixation.

The topic of metatarsal fractures can be a comprehensive microcosm of orthopedic trauma. The variety of injuries can include simple non-displaced fractures, stress fractures, joint dislocations, intra-articular fractures, severely comminuted and even compound fractures. The surgeon must have a thorough working knowledge of these injuries in the specific region and unique anatomy of the forefoot. The full scope of potential injury must be appreciated to avoid misdiagnosis and inappropriate treatment.

The variety of injuries to the metatarsal region can be systematically classified. This type of classification can serve the same purpose as the Lauge-Hansen system in ankle fractures. A working knowledge of the mechanism of injury is also the key to successful management of many of the common injuries through conservative methods or closed reduction techniques.

Complete clinical and radiographic evaluation are essential stepping stones in the successful management of metatarsal fractures. A detailed description of the clinical appearance of the injury may often be the clue to a major injury that may not be fully radiographically demonstrated because of spontaneous reduction. A minimum of three radiographic views, dorsoplantar, lateral, and oblique, are essential in the initial evaluation of any forefoot trauma that may include metatarsal fractures.

Armed with a full appreciation of potential injury patterns the surgeon must apply a similar advanced level of practice to the techniques of management. Conservative methods or closed reduction techniques do not necessarily fall into the category of outdated skills. Indeed, Charnley presents a scientific basis to the principles and techniques of closed reduction in his text *The Closed Treatment of Common Fractures* (Ref. 2). The scientific application of the principles of closed reduction include:

1. the mechanism of injury
2. the soft tissue hinge
3. the closed reduction technique
4. maintenance of the reduction via the plaster.

These basic concepts are extremely important for effective and consistent results through closed methods.

Open reduction and internal fixation of metatarsal fractures may be more fashionable in the recent surgical theater. While there are definitive indications for ORIF, such as intra-articular fracture and severe non-reducible deformity, the indications for ORIF in more common injuries remains less distinct. It is through a combined appreciation of a more normal functional result and the concepts and skills of rigid internal fixation that a logical approach to the management of metatarsal fractures can be devised.

Classification

A working outline for categorization of metatarsal fractures can be summarized as follows:

I. General Fractures
   A. Location
   B. Configuration

II. Special Categories
   A. First metatarsal fractures
      1. Biomechanical significance
      2. Avulsion peroneus longus
   B. Fifth Metatarsal Fractures
      1. Avulsion Fractures
      2. Jones' Fractures
   C. Intra-articular Fractures (includes fracture/dislocation)
      1. Lisfranc Joint
      2. Metatarsophalangeal Joint
      3. Metatarsocuneiform/cuboid Joint
   D. Stress Fractures
   E. Epiphyseal Fractures
   F. Open Fractures

General Considerations in Metatarsal Fractures

The general topic of metatarsal fractures is very poorly described in general orthopedic and podiatric literature. Most attention has been focused on specific and definable injuries such as the Jones' fracture, Lisfranc injury, and avulsion fractures of the base of the fifth metatarsal. Common fractures of the metatarsals are casually described as being caused by direct trauma or some form of impaction. While a detailed knowledge of the mechanism of injury for common fractures may not be essential to successful management, it does demonstrate the level of minor significance that common metatarsal fractures have been given.

Neck Fractures

The most common fractures at the level of the metatarsal neck are transverse or short oblique in configuration. Transverse fractures are typically bending fractures caused by direct trauma from a falling object. One of the most common transverse fractures at the metatarsal neck, however, is not caused by direct trauma but rather fatigue as seen in the typical stress fracture of the lesser metatarsals.

The short oblique fracture at the neck of the metatarsal is caused by a bending force applied with longitudinal compression as seen in the "brake foot" following an automobile accident. Direct pressure is applied through the plantar surface of the metatarsal heads forcing the metatarsal head up and back. A similar mechanism can create a short oblique fracture with plantar displacement or angulation of the metatarsal head. This injury can occur with extreme extension of the digit on the metatarsal head and an impaction force causing a violent plantar bending force at the metatarsal neck. Similar displacement can also occur in either a medial or lateral direction depending on the angle of pressure directed against the metatarsal head.

Mid-shaft Fractures

The same mechanical forces can create fracture at the mid-shaft level of the metatarsal. Direct impact from a falling object is likely to create a transverse fracture pattern. Long oblique fractures of the metatarsal involving the mid-shaft region can be seen with direct linear impact through the longitudinal axis of the metatarsal. Torsion fractures of the metatarsals are rare.

Base Fractures

Fractures identified at the base of the metatarsals must be suspicioned as "tell tale" signs of more major injury. Small obscure fractures such as an avulsion fracture from the base of the second metatarsal may be suggestive of a more significant fracture/dislocation of the Lisfranc joint. Transverse fractues can occur at the metatarsal bases without disruption of the tarsometatarsal joint.

Other factors must also be taken into consideration in evaluation of metatarsal fractures. Displacement, angulation deformity, shortening, and comminution will play major roles in determining the most appropriate form of treatment for each fracture.

Special Categories of Metatarsal Fractures

The grouping of special categories serves several purposes. Many special fractures occur only in specific metatarsals and are caused by unique and well defined mechanisms of injury. Certain fractures have significant functional or healing significance. Each of the categories will be discussed briefly as they have been described in detail in other references.

First Metatarsal Fractures

Fractures of the first metatarsal carry special significance because of the primary functional role of the first ray segment. Any fracture that creates significant shortening or angular deformity of the first metatarsal can significantly alter the overall biomechanical function of the ray and the foot as a whole.

A unique fracture of the plantar lateral aspect of the base of the first metatarsal can be produced by traction of the peroneus longus tendon. An avulsion fracture involving the insertion of the peroneus longus is a rare but specific fracture unique to the first metatarsal. Other subtle fractures of the first metatarsal base may be seen in Lisfranc injuries.

Fifth Metatarsal Fractures

The fifth metatarsal is subject to the same type of general fractures as the other metatarsal segments. However, two unique fractures to the fifth metatarsal are classically described.

Avulsion fracture. Avulsion of the styloid process of the base of the fifth metatarsal is classically described as a consequence of an inversion injury of the foot and is a direct result of traction from the peroneus brevis tendon. This fracture usually heals with minimal complications. However, significant displacement can occur with separation of the fracture fragments due to pull of the peroneus brevis tendon and may require surgical intervention for reduction and fixation.

Jones' fracture. The classic Jones' fracture is a transverse fracture at the base of the fifth metatarsal approximately one centimeter distal to the metatarsocuboid joint. It has been historically labeled as a poor healing fracture due to decreased vascularity of the metaphyseal segment of the metatarsal base. However, this concept is unsupported and more logically explained on the basis of mechanical instability of this unique fracture location. The proximal end of the fifth metatarsal is securely immobilized by ligamentous attachment, interlocking joint articulation, and insertion of a major tendon.

The distal segment of the fifth metatarsal, unlike the internal metatarsals, is only stabilized by intermetatarsal attachments on one side. The distal segment of the fifth metatarsal is subject to motion in any phase of weightbearing and acts as a highly mobile lever arm with motion focused at the proximal fracture site. It is this mechanical instability and unrestrained motion that predisposes this unique fracture to delayed union and even non-union.

Intra-articular Fracture

Intra-articular fractures in general are a unique and special category. Fracture involving metaphyseal and subchondral bone with resultant damage to articular cartilage can produce permanent disability more than any other fracture. In these instances the idealistic principles of anatomic reduction and rigid internal fixation are paramount for successful healing with minimal disability and loss of joint function.

Lisfranc joint

One of the most disabiling injuries to the foot includes the multiple and complex fracture/dislocation of the tarsometatarsal or Lisfranc joint. Cain summarized the injury in his presentation at the Doctors Hospital Seminar in 1985. Wiley's article *The Mechanism of Tarsometatarsal Joint Injuries* gives a classic description of the classifications and different mechanisms involved (3).

Metatarsophalangeal Joint

Intra-articular fracture into the metatarsophalangeal joint is not a commonly encountered injury. Injury into the joint more commonly involves the base of the proximal phalanx rather than the articular aspect of the metatarsal head. As with any intra-articular fracture accurate anatomic reduction and rigid internal fixation are the primary goals in treatment.

Stress Fractures

Stress fracture of one or more of the intermediate three metatarsals is one of the more common fracture injuries of the metatarsals. The basic etiology of is repeated excessive load force to the metatarsal with resultant fatigue or stress fracture at the weakest point of the bone. Clinical conditions that can lead to this injury include:

Over-use syndromes seen in athletes, military personnel, occupational settings and other high stress activities.

Functional imbalance seen in biomechanical conditions and iatrogenic surgical disorders.

Osteoporosis

The typical stress fracture is a non-displaced transverse fracture at the neck of the metatarsal. The injury is often misdiagnosed early on in the clinical presentation due to lack of radiographic evidence of fracture or bone healing. The fracture is classically identified two to three weeks into the clinical course as active bone callus becomes evident in the healing process.

Epiphyseal Fractures

The unique category of epiphyseal fractures is classically described in the Salter-Harris classification system. Banks presents a discussion and lecture in the 1987 edition of the Doctors Hospital Surgical Seminar syllabus on this topic. The same basic classifications and prin-

ciples of treatment can be applied to epiphyseal fractures of the metatarsals.

Open Fractures

Open or compound fractures present special treatment considerations. The basic fractures are no different from those mentioned above other than the environment within which they exist.

There are many other unique and challenging injuries that can involve the metatarsals such as crush injuries, amputation, and even missile wounds. Each of the special areas offers additional considerations in the overall treatment plan.

Treatment

Treatment of metatarsal fractures has historically been left to the personal experience of the individual surgeon. Very little is written regarding basic guidelines, indications, or criteria. Techniques also vary with each physician and most often fall into the basic realm of a below-knee cast or fracture shoe. Open reduction and internal fixation of metatarsal fractures has previously had very few primary indications. This rather outdated approach is merely reflective of the traditional goal of management of metatarsal fractures, i.e. to allow the bone to heal.

With a greater appreciation of the complex and integral function of the metatarsals as a unit, the modern goals of treatment are more oriented toward the functional end result. The primary goal of fracture treatment of the metatarsals is to return the injured part to full function with minimal sequellae to the individual and adjacent structures.

The key components of this surgical philosophy include anatomic reduction and the principles and techniques of rigid internal fixation. Conservative management through the principles and techniques of closed reduction and external plaster fixation are still the primary and initial basis of treatment for most of the common metatarsal fractures. However, the surgeon must be aware of those more complex injuries which will require surgical intervention and the unique and advanced skills of rigid internal fixation.

The clinical conditions and the techniques of open reduction and internal fixation of metatarsal fractures will be discussed in detail in the lecture presentation of metatarsal fractures at the 1987 Doctors Hospital Surgical Seminar.

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