

Fifth Metatarsal Base Fractures: Literature Review and Treatment Guideline

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The Northern Ohio Foot and Ankle Journal 2 (7): 1

Abstract: The fifth metatarsal base fracture is commonly seen by the foot and ankle surgeon. Understanding the anatomy and pathophysiology, as well as the common fracture patterns is important to formulate a treatment plan. The standard of care for the avulsion fracture is with functional immobilization with reproducible results. The meta-diaphyseal Jones fracture and the diaphyseal stress fracture can be more challenging to treat. These fractures have a notable failure rate with conservative treatment and may require surgical intervention, dictated by both patient variables and surgeon's experience. The pathology of these fractures is discussed in detail and an evidence based treatment guideline is formulated.

Key words: Fifth metatarsal fracture, Jones fracture, stress fracture, forefoot fracture

Accepted: July, 2015

Published: July, 2015

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The fifth metatarsal base fracture is a very common fracture with an incidence of 6 per 100,000 annually [1]. Rammelt et al stated it to be the most common fracture of the forefoot [2]. Up to 70% of metatarsal fractures involve the fifth metatarsal and 80% of fifth metatarsal fractures involve the proximal aspect of the bone [3,1]. These fractures have a greater incidence in males in their third decade and females in their seventh decade, with a greater prevalence in women with low bone mineral density [4].

Anatomy

The fifth metatarsal has certain unique anatomical features. The fifth metatarsal has a natural lateral bowing from proximal to distal, with the proximal aspect oriented more dorsal. Two tendons, the peroneus tertius (pt) and peroneus brevis (pb) invest their insertion on the base of the fifth metatarsal. The pb inserts on the proximal dorsal and lateral aspect of the base, whereas the pt inserts slightly distal dorsal and more medial relative to the pb. Three ligaments, the lateral band of the plantar fascia (lbpf) and the dorsal and plantar fourth to fifth metatarsal ligaments also insert on the fifth metatarsal base. The lbpf insertion is at the most proximal and lateral aspect of the base. These soft tissue insertions are important to understand when considering fracture pattern and stability.

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The fifth metatarsal articulates with the cuboid and the fourth metatarsal. This articulation between the fourth and fifth metatarsals and the cuboid allows for much of the motion seen in the midfoot and lateral column. Choi et al found that fifth metatarsal base fractures that are displaced or comminuted can result in significant disruption of the cuboid–fifth metatarsal joint [5]. Therefore, these fractures may require open reduction and internal fixation to prevent post traumatic arthritis.

During growth, the fifth metatarsal base has a secondary growth center which fuses around age 16 to form the styloid process. The clinician must be cognizant of two bony anomalies. The first anomaly is the os vesalianum which forms when there is incomplete closure of the secondary growth center. The os vesalianum lies within the pb tendon near its insertion on the base. The second and more common anomaly is the os peroneum. This accessory bone exists within the distal coursing of the peronus longus tendon. Both of these anomalies can be symptomatic and may be mistaken for a fracture.

The vascular anatomy of the fifth metatarsal was described in detail by Smith in 1992. Proximally and distally within the metaphyseal bone, small metaphyseal vessels provide extensive perfusion. The diaphyseal region of the bone is supplied by a nutrient artery which enters the bone medially and slightly proximal from the middle of the bone. The larger diaphyseal vessels anastomose with the metaphyseal vessels at the meta-diaphyseal junction. Smith proposed that fractures at this junction have poor healing potential due to its tenuous blood supply [6]. Lastly, the lateral dorsal cutaneous nerve (LDCN) which is the distal extension of the sural nerve innervates the lateral foot and courses into its distal branches at the level of the fifth metatarsal. Fansa et al investigated injury to the LDCN and felt that iatrogenic nerve injury is underreported [7]. Their cadaveric dissections found the LDCN was located superficial (ie, lateral) and inferior to the superior

border of the pb tendon in all specimens and at all reference points.

Biomechanics

During stance phase, the center of pressure moves progressively to the lateral column [8]. When stressed, anatomy of the fifth metatarsal directs forces to the base of the bone [9]. The metaphyseal-diaphyseal junction will operate as a fulcrum for movement. Any deformity that will place increased stress on the lateral column can predispose patient to fifth metatarsal base fractures including hindfoot varus, cavus foot type, and metadductus [10]. Yoho et al compared 30 patients with meta-diaphyseal fractures to a control group of 30 asymptomatic persons [11]. Interestingly, patients that had sustained a Jones fracture also had a greater amount of metatarsus adductus when compared to the control group.

Classifications

Multiple classification systems have been made based on anatomic location and stages of fifth metatarsal base fractures. For instance, Stewart in 1960 created a classification based on anatomic location and joint involvement [12]. In 1984, Torg et al created a classification based on historical and radiographic examination [13]. Per Torg, acute fractures are characterized by a narrow fracture line and absence of intramedullary sclerosis. Delayed union is associated with widening of the fracture line and evidence of intramedullary sclerosis. Lastly, non-union has complete obliteration of the medullary canal by sclerotic bone. The classification by Lawrence and Botte in 1993 is simple and clinically applicable separating the three most common fracture patterns as tuberosity (metaphyseal avulsion), Jones-type (meta-diaphyseal), and diaphyseal (stress fracture) [14]. More recently, Mehlhorn et al devised a new classification system based on the amount of medial joint involvement [15]. They found that fractures with more medial joint entry of the fracture line were associated with 45% risk of displacement.

Clinical Presentation

Patients typically present with a recent history of indirect trauma with chief complaint of pain, swelling, decreased range of motion and tenderness over the lateral aspect of the foot. Some patient may have a prodromal period with lateral foot pain prior to the fracture. Differential diagnosis includes ankle sprain, peroneal tendonitis/tenosynovitis, os peroneum syndrome, os vesalianum syndrome, apophysitis, cuboid syndrome, calcaneo-cuboid arthritis, fourth/fifth metatarsal-cuboid arthritis and fracture of anterior process of calcaneus. After a thorough history and physical examination, radiographs should be ordered for a definitive diagnosis.

Metaphyseal Avulsion Fracture

Of the three fracture patterns that are associated with the fifth metatarsal base, the metaphyseal avulsion fracture constitutes 93 percent of these fractures [16]. The metaphyseal fracture is also termed an avulsion, styloid, or tuberosity fracture. It was postulated that the sudden traumatic pull of the peroneus brevis on a plantarflexed and inverted foot was the cause of this acute avulsion [17, 18]. This thought process has been challenged since the insertion of the peroneus brevis is more distal than the site of an avulsion fracture [19, 20, 21]. Also, the dynamic pull of the peroneus brevis would cause instability of the fracture fragment. Clinically, the avulsion fragment seems rather stable and patients usually heal with conservative treatment. Devries et al looked closely at the insertions of the pb and lbpf on the fifth metatarsal base in cadaveric specimens [22]. The orientation of the insertion of these soft tissues is such that the traumatic tensioning of the lbpf would cause the typical avulsion fragment. They found that there is limited motion allowed superficially and laterally by the lbpf. Hence, these fractures can be treated non-surgically with immobilization and full weight bearing since the fracture should not be subject to significant dynamic force. Polzer et al found that those patients treated functionally (post op shoe, orthopaedic shoe, elastic

dressing, tubigrip, Jones dressing) for an avulsion fracture returned to their pre-fracture functional status significantly sooner than those that were immobilized in a short leg cast [23].

Meta-diaphyseal Jones Fracture

The meta-diaphyseal junction fracture constitutes 4% of proximal fifth metatarsal fractures [16]. These fractures are termed Jones fractures, named after Sir Robert Jones who first described these fractures in 1902. Sir Jones felt that these fractures were not caused by direct trauma to the bone but instead, by "indirect violence" [17]. Kavanaugh et al stated the mechanism of injury to be a vertical force or a mediolateral force applied to the lateral aspect of the plantarflexed foot [24]. Whichever position the foot is in during the traumatic event, it seems that patients relate experiencing some form of indirect trauma with subsequent lateral foot pain.

Sir Jones stated that the fracture was consistently located approximately three-fourths of an inch from its base [17]. Richli et al found the meta-diaphyseal fracture at least 1.5 cm from the metatarsal base but can be up to 3 cm distal to fifth metatarsal tuberosity [21].

The Jones fracture has suboptimal long term outcomes with non-operatively treatment, with failure ranging from 25% to 44% [7]. Dameron et al noted a 25% nonunion rate in non-operatively treated patients [25]. A randomized study by Mologne et al found early 8 week cast immobilization has a higher non-union rate than early screw fixation [26]. They concluded that operative treatment reduced time to union and return to sport in nearly 50% of patients. Nunley et al found that full function was prolonged by 5.5 months for non-operatively treated Jones fractures [19].

Much debate continues as to why these fractures have such a poor prognosis with conservative treatment. As stated earlier, Smith inferred the tenuous vascularity to be the factor to poor healing [6]. Morris

et al challenged Smith's vascularity theory since the operative treatment (orif) utilizes a mechanical solution to a supposedly vascular problem [27]. Morris utilized cadaveric specimens under two loading conditions. One was a simulated fracture distal to the pb insertion (Jones equivalent) and the other was a simulated avulsion fracture. They found that Jones type fractures which are distal to the pb insertion were significantly more unstable than the more proximal fracture. They concluded that a mechanical component may be the cause of the poor healing potential of the Jones fracture due to deforming forces exerted by the pb tendon. This may explain why Jones fracture that are stabilized with orif have a greater healing rate than those treated non-operatively.

Diaphyseal Stress Fracture

The diaphyseal fracture constitutes 3% of all proximal fifth metatarsal fractures [16]. These fractures may be termed pseudo Jones fractures since they can be easily mistaken for true Jones fractures due to their close proximity. Chuckpaiwong et al believed that the differentiation between these fracture types is not necessary because the treatment and outcomes are not significantly different between the two fractures [28]. Polzer et al formulated a new classification which placed both the true and pseudo Jones fractures into one group and recommended early intramedullary screw fixation for both [23].

Although treatment indications may be similar for both the true and pseudo Jones fractures, the underlying pathology differs. Unlike the Jones and avulsion fractures which are caused by a single indirect traumatic event, the diaphyseal fracture is more of a stress fracture caused by minor repetitive trauma that incurs over time. Patients may complain of a prodromal period of lateral foot pain and likely have cortical changes and bone marrow edema prior to sustaining a complete fracture. These patients often have a cavus foot type, a varus heel, or metatarsus adductus which places more weight and load to the

lateral foot. Surgical correction of the underlying deformity as well as the fracture may be needed.

Operative Treatment

Fixation of the fifth metatarsal base fracture is typically done with intramedullary (IM) screw placement. This approach is minimally invasive, shortens operative time, and offers sound and reproducible results. Remembering the lateral bowing of the fifth metatarsal, a useful technique pearl is to start the IM screw "high and inside". This technique will allow the screw to run down the medullary canal and prevent cortical breach. IM screw sizes can range from 4.0 to 6.5 mm with the most common size being a 4.5 mm. Smaller screw sizes have been associated with non-union. When too large of a screw is used, cortical breach and diastasis of the fracture site may ensue with failure of bony healing. Titanium or stainless steel screws can be used for fixation. Devries et al performed a retrospectively review comparing titanium and stainless steel screw fixation in Jones type fractures [29]. They found that the decision to use stainless steel or titanium can be left to patient constraints, such as allergies, or physician preference without compromising the clinical result. Pietropaoli et al compared the strength of cannulated and non cannulated screws [30]. Their biomechanical study found no significant difference in force to initial or complete displacement with either screw type.

Some other forms of fixation such as tension band and cerclage wiring as well percutaneous k-wire fixation are used if IM screw placement fails or if the fracture is too comminuted. Inlay bone grafting and plating are often reserved for reconstructive procedures or salvage efforts to replace hypo or hypertrophic bone formation, to regain length at the fracture site and allow for a stronger construct. Bicortical screw fixation is also an option and has been shown to be a stronger construct with a greater load to failure when compared to IM screw placement [31]. There is risk of mal reduction as well as prominence and impingement symptoms from bicortical screw fixation. Choi et al reviewed the use of mini-hook plates [5]. The most proximal hole functions as a hook for the application of a compression force. They found that fixation using the

mini-hook plate achieved favorable results in displaced and comminuted fifth metatarsal fractures.

Post-Operative Management

Surgery has three tiers, all of which are equally important and must be fulfilled for surgical success. The first tier is the surgeon choosing the appropriate procedure for the specific patient and pathology. The second tier is the surgeon performing the stated procedure in the appropriate manner. The third and last tier is the patient's investment in following the post-operative instructions with strict compliance. Hence, educating the patient on the expectations during the postoperative period and the need for compliance is of utmost importance to have the best surgical outcome. The typical post-operative regimen consists of non-weight bearing in below the knee cast or splint with transition to partial weight bearing in a removable cast walker until complete bony union is achieved per radiographic studies. Once the patient has healed, the use of orthotics may be indicated especially in patients that have underlying foot deformity [11]. This is done to prevent recurrent symptoms or fractures. A major predictor to failure of surgery is early return to activity, especially in the elite athlete [32]. Again, to have a good outcome, delayed return to regular activity until there is radiographic evidence of solid union is needed.

Pediatric Patients

Herrera-Soto et al found that most fractures of the fifth metatarsal in the pediatric population do well clinically after a course of walking cast unless the fracture is an intra-articular fracture type or the fracture occurs in the proximal diaphyseal area [33]. They concluded that most pediatric fifth metatarsal fractures behave as those found in adults and can be treated similarly. One must remain cognizant of the secondary growth center as well as the accessory ossicles since both of these anomalies can become symptomatic and may require removal. These anomalies are often mistaken for an avulsion fracture.

In fact, Ralph et al found traction apophysitis of the fifth metatarsal base, also known as Iselin's disease, is commonly misdiagnosed as a fracture [34]. Riccardi et al had agreeable findings. In their retrospective radiographic review, they found that out of 115 patients initially diagnosed with a fracture only 12.8% of all cases truly had a fracture [35].

Conclusion

Understanding the local anatomy, biomechanics, pathophysiology, and the different fracture patterns is important to formulate an appropriate treatment plan. The recent literature supports that the avulsion fracture is caused by the traumatic pull of the lateral band of the plantar fascia. Functional immobilization in a stiff soled shoe with full weight bearing is the standard of care with predictable and satisfactory outcomes. The meta-diaphyseal Jones fracture has a 25% rate of failure with conservative treatment. Current thought has rebuked Smith's theory that the tenuous vascular supply at the meta-diaphyseal junction is the cause of poor healing. Instead, current publications have found that mechanical instability at the meta-diaphyseal junction is the cause of poor healing with conservative treatment and that mechanical correction using orif has good and predictable results. Diaphyseal stress fractures also have a greater rate of failure with conservative treatment. These fractures may also require orif as well as correction of any underlying deformity. Creating a treatment guideline based on current evidence will assist the foot and ankle surgeon in treating this fracture. As always, communication, patient education and setting appropriate patient expectations is of utmost importance when any surgical procedure is performed.

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