CHAPTER **28**

PROXIMAL FIFTH METATARSAL FRACTURES AND THE ASSOCIATION WITH METATARSUS ADDUCTUS FOOT TYPE.

Lindsay H. Russell DPM
Ryan Tingle DPM
Dean Nakadate DPM

Fractures of the proximal fifth metatarsal are frequently encountered injuries. Several notable publications have addressed these fractures throughout the past century with Sir Robert Jones 1902 series being the first to present cases with radiographic evidence of the fracture site. The mechanism of injury, prognosis, classification of these fractures, and the need for surgical intervention has been thoroughly debated in numerous publications. In spite of this debate, or more likely because of the debate confusion regarding the diagnosis and treatment is common even today.

More recently most authors would agree that these fractures typically occur in three distinct anatomical regions of the proximal fifth metatarsal. These are: 1) the tuberosity (styloid process), 2) the base (region corresponding to the fourth and fifth inter-metatarsal articulation), and the 3) metaphyseal-diaphyseal region (proximal one third of the diaphysis)[23] (Figure 1). Metaphyseal-Diaphyseal fractures have been further sub-classified as acute and stress related injuries.[35,36]

Tuberosity fractures commonly called "avulsion" fractures are the most common fifth metatarsal fracture.[24] Confusion and controversy has surrounded base and metaphyseal-diaphyseal fractures of the fifth metatarsal both of which have been identified as a "Jones Fracture". Therefore the term "Jones Fracture" has mistakenly become associated with all fractures of the proximal fifth metatarsal.

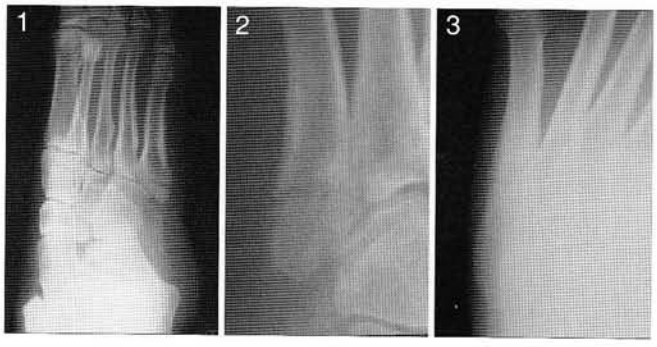

Figure 1. 1)Tuberosity Fracture. 2) Base Fracture involving 4th and 5th metatarsal base articulation. 3) Metaphyseal-Diaphyseal Fracture.

Avulsion fractures were originally believed related to excessive pull of the peroneus brevis muscle tendon while inverting the foot and ankle. However the broad insertion of the peroneus brevis tendon makes this an unlikely cause in most fractures.[25,30] More recent cadaveric studies have linked a portion of the lateral band of the plantar aponeurosis to the avulsion fracture.[27] In terms of fractures distal to the tuberosity, the mechanism of injury is still not clearly understood. However, the injury is believed to be related to a sudden very strong adduction force applied to the firmly grounded forefoot while the ankle is plantar-flexed.[23] Stress related fractures could also occur when a larger than normal load is repeatedly applied to the fifth metatarsal over relatively short periods of time.[30]

The authors are not aware of any particular structural foot types that have been associated with avulsion fractures of the fifth metatarsal. In terms of fractures distal to the tuberosity, Sammarco related both cavus and planus foot types to what he called the chronic or stress-related "Jones fracture".[30] In more recent publications by Theodorou et al and Saxena et al, structural adduction of the forefoot or metatarsus adductus has been related to stress fractures in the foot. Theodorou et al reported an association between stress fractures of the lateral metatarsals and metatarsus adductus.[34] Saxena et al presented 5 cases of fourth metatarsal base stress fracture, three of which had associated forefoot adduction.[29] To the authors' knowledge, no publication has reported an association between metatarsus adductus foot type and acute proximal fracture of the fifth metatarsal.

In the current study, consecutive cases of acute proximal fifth metatarsal fracture presenting to the senior author (DN) were evaluated for associated radiographic evidence of metatarsus adductus. Treatment type and length of time until return to daily activities was also recorded.

BACKGROUND

The Infamous Jones Fracture

Among the first and certainly the most famous publication regarding fifth metatarsal fractures was reported in 1902 by Sir Robert Jones. Jones reported six cases (the first being himself) of fifth metatarsal fracture located approximately "three-fourths of an inch from its base". The significance of the article is certainly related to the first radiographic demonstration of this particular fracture. In addition, Jones also eliminated the theory that all metatarsal fractures were related to "direct" blow as opposed to" indirect" forces. The mechanism of injury according to Jones was related to transmission of excessive body weight through a foot fixed in an equinovarus position. As previously stated Jones' report was so significant that his name has been loosely associated with any and all fractures of the proximal 5th metatarsal.[17]

In 1927 Carp reported on 21 fractures of the fifth metatarsal with special emphasis placed on delayed union. Five of the 21 fractures showed clinical and radiographic evidence of delayed union. Four of the five delayed unions were fractures of the fifth metatarsal base region, excluding tuberosity fractures. Carp felt that poor blood supply to the fifth metatarsal was likely the main cause for delayed union.[8]

An anatomical classification of fifth metatarsal base fractures was proposed by Stewart in 1960. Of the 51 consecutive cases, four initial types of fracture were described with particular attention directed to anatomical location of the primary fracture line. Type 1 fractures occurred at the junction of the shaft and base of the metatarsal or as Stewart describes corresponding "approximately at the distal limit" of the fourth and fifth inter-metatarsal articular facet. Type 2 is an intra-articular (corresponding to the fifth metatarsal cuboid joint) avulsion fracture of the tuberosity. Type 3 is an extraarticular avulsion fracture of the tuberosity. Type 4 is a comminuted intra-articular fracture of the base. Stewart later added a fifth type relating to fracture of the tuberosity in children with visible apophysis. Stewart did acknowledge the fact that certain fractures may occur at "intermediate levels". It is unclear whether or not an intra-articular fracture of the fourth and fifth metatarsal base region would be considered a type 1, type 2 or type 3 fracture. None the less he emphasized symptomatic treatment with seldom use of plaster immobilization and he reserved open reduction for severely displaced or comminuted fractures.[33]

Dameron et al reported 125 fractures of the proximal fifth metatarsal separted into tuberosity fractures and proximal shaft fracture occurring in the "1.5 centimeter segment just distal to the flare". They reported that almost all of the 100 tuberosity fractures were healed clinically at three weeks and radiographically at two months with symptomatic elastic bandaging, partial weightbearing and occasional use of crutches. Of the 20 proximal shaft fractures five went onto symptomatic non-union with eventual sliding bone graft. Eleven patients with proximal shaft fracture were treated symptomatically while the other nine were immobilized in plaster. In conclusion, Dameron recommended individualized treatment of these proximal shaft fractures. However, he noted that they often do not fare well and early bone-grafting should be considered in professional athletes.[10]

One of the most significant publications reporting consistently poor healing potential of the "Jones" fracture was reported by Kavanaugh et al in1978. In a series of 22 patients who sustained fracture to the proximal diaphysis of the fifth metatarsal (no specific anatomical landmarks were defined) twelve of the eighteen treated conservatively (66.7%) went on to delayed union. Kavanaugh related this troublesome injury to a stress fracture as opposed to always occurring in an acute traumatic event. Forty-one percent of the fractures were associated with prodromal symptoms prior to radiographic evidence of fracture. With these findings the belief that "Jones" fracture was related to an inversion injury was disputed. Kavanaugh supported the concept that related these fractures to excessive amounts of force distributed through the lateral column of the foot with ambulation. He advocated intramedullary screw fixation for athletes who sustain these fractures. Subjects who underwent early fixation returned to full activity levels six to eight weeks post-operatively.[19]

Delee et al also advocated early surgical fixation of fractures occurring in the proximal 1.5 cm of the fifth metatarsal shaft. In a series of ten athletes with stress fractures, confirmed by prodromal discomfort to the lateral foot prior to acute fracture, axial intramedullary screw fixation was performed. All fractures were reportedly unionized in an average of 7.5 weeks with return to full activity levels by an average of 8.5 weeks post-operatively. Unlike a 45% complication rate reported by Kavanaugh with intramedullary screw fixation, Delee reported minimal complications which were all remedied by shoe-gear accommodation. Hence intramedullary screw fixation was advocated secondary to its minimal invasiveness, decreased risk of infection and ability to be performed on an outpatient basis.[11]

In 1979, Zelko et al reported on 21 fractures of the proximal diaphysis of the fifth metatarsal (1.5 cm segment distal to the tuberosity). Twenty of the fractures

occurred in athletes and both acute and stress related injuries were included in the study. Healing times required a minimum of three months with bone grafting while some fractures were still not radiographically healed at 20 months. It was felt that the clinical course was not influenced by initial conservative treatment and Zelko advocated bone grafting with corticancellous graft after thorough curettage.[38]

In another classic work, Torg et al classified fifth metatarsal base fractures distal to the tuberosity radiographically and provided both conservative and surgical treatment guidelines associated with the fractures radiographic appearance. Over a nine year period, 46 fractures were presented and were evaluated radiographically. Three types of fracture were described. The first represented acute injury with a narrow fracture line and absence of intramedullary sclerosis. The second group radiographically appeared to be delayed in union with a widened fracture line and intramedullary sclerosis. Finally a third group represented those injuries that presented as a non-union with sclerotic bone obliterating the medullary canal. Torg's choice of surgical treatment advocated medullary curettage with inlay autogenous bone graft.[35,36]

Torg recommended non-weightbearing immobilization for the acute injury as fourteen of fifteen patients treated in this manner healed in a mean time of seven weeks. Only four of the other 10 acute injuries went onto union after treatment with various weightbearing techniques. Delayed union fractures could initially be treated with conservative immobilization. Seven of the ten patients went onto union. However, the mean healing time was 15.1 months. The other three required surgical intervention. The point should be made that these ten patients were not placed on a non-weightbearing status, a recommendation that Torg later advocated for conservative treatment of delayed union.[35] Nine patients with initial presentation of non-union underwent medullary currettage and inlay bone graft. Eight of these healed in a mean of eight months. A total of twenty patients were treated surgically, nineteen of which progressed to complete healing.[36]

Since the work of Torg, several authors have published review articles clarifying the proximal fifth metatarsal fracture, presenting individual cases and summarizing treatment recommendations.[1,20,23,26,30] Variances in terminology and anatomic placement are still reported. However, most authors understand that the original fracture reported by Jones (which he implied was at risk for prolonged symptoms and possible non-union), occurs in the region of the proximal 5th metatarsal shaft just distal to the fourth and fifth metatarsal base articulation. The fact that so many authors have defined the area of "Jones Fracture" in terms of a specific site, (¾ of an inch from the metatarsal base... within the articulation of the fourth and fifth metatarsal bases... within 1.5 cm of the proximal shaft... within 1.5 cm of the tuberosity... the proximal part of the diaphysis distal to the tuberosity... at the base and occasionally in the proximal shaft... transverse fracture through the proximal part of the fifth metatarsal) has without doubt contributed to the confusion related to this specific injury. In 1999, Landorf attempted to clarify the confusion by classifying the fracture in question into either a proximal diaphyseal stress fracture or an acute proximal diaphyseal fracture. He altogether avoided the use of the term "Jones Fracture" avoiding any confusion with the infamous eponym.[20]

Metatarsus Adductus

Metatarsus Adductus is a structural foot deformity of the metatarsals in the transverse plane.[3] Throughout history the deformity has commonly been referred to as metatarsus varus, pes varus, parrot foot, C foot, hooked foot, pigeon toe, and metatarsus internus.[3,5] The etiology, prognosis and treatment of metatarsus adductus is still controversial in the present clinical setting.

The incidence of metatarsus adductus has been reported to be 1 in 1000 live births.[3] Multiple theories exist regarding the etiology of metatarsus adductus with an emphasis placed on whether or not children are born with the deformity or they acquire the deformity after birth. Several authors favor abnormal intrauterine pressure as the most likely cause. Absence or deformity of the medial cuneiform, abnormal positioning and pull of surrounding musculature (including tibialis and abductor hallucis musculature) and congenital deformity have also all been reported as causes of metatarsus adductus.[3]

The diagnosis of metatarsus adductus has been reported clinically and radiographically. In terms of radiographic diagnosis the metatarsus adductus angle is described as the angle formed between the bisection of the second metatarsal and the bisection of the lesser tarsus on dorso-plantar weightbearing films[15] According to Yu and Dinapoli 15-20 degrees is considered a mild deformity, while 20-25 degrees is considered moderate. Any measurement above 25 degrees is considered severe. Sgarlato felt that the normal range of metatarsus adductus angle was 10-20 degrees with 15 being the average. Anything over 20 degrees was considered a metatarsus adductus foot type.[31]

Since the lesser tarsal bones are not well formed in the infant, metatarsus adductus must be estimated by the relationship of the forefoot to the rearfoot. Ganley described the immediate non-weightbearing appreciation of metatarsus adductus in the infant by evaluating the

attitude, relationship and movement of the forefoot compared to the rearfoot.[3] Bleck bisected the heel and compared the distal extension of this bisection to the digits. A structurally normal foot should display the extension of the heel bisection between the second and third toes. Mild deformity bisects the third digit. Moderate deformity bisects the third and fourth digits while severe deformity bisects the fourth digit or further lateral.[5] (See Figure 2) Engel et al and Lepow described other techniques to evaluate metatarsus adductus in the newborn foot as ossification of the tarsal bones is not yet complete.[3]

The treatment recommendations for metatarsus adductus have also been controversial. Most of this controversy centers around the decision to treat the deformity or leave it alone to resolve on its own. Most authors feel that treatment is indicated in the patients whose deformity can be classified as moderate or severe without the ability to passively correct the forefoot (rigid). For patients in which the decision to treat the deformity has been made, conservative manipulation, serial casting and splinting is indicated prior to the age of nine months. In children greater than two years of age or who have failed conservative therapy, soft tissue correction has been advocated. However, long term results of procedures such as the Heyman, Herndan and Strong have not passed the test of time. Osseous correction of the deformity may be considered in persistent severe rigid deformity when children have reached the age of eight years old.[3]

In 1983, Bleck presented a retrospective study in 160 children with metatarsus adductus. He concluded that regardless of the severity of deformity the only predictable indicator of a successful outcome was the age of the patient when conservative treatment commenced. Failure to treat moderate to severe deformities would result in extensive surgical correction.[5] Bohne echoed the findings of Bleck in a series of 152 children with metatarsus adductus stating that conservative treatment before the age of 9 months was advocated for correction of deformity and prevention of future symptomatology.[6]

Most of the published literature on the metatarsus adductus foot type in adolescence and adulthood has focused on the sequelae related to poor fitting shoe gear, and resultant foot deformities such as the "serpentine" or "Z-shaped" foot. There have been several publications relating metatarsus adductus to hallux abducto-valgus in both adults and adolescent patients. Banks et al reported on 72 feet of patients under the age of twenty-one that underwent bunion surgery. Forty-eight of the seventy-two feet had metatarsus adductus angles greater that 15 degrees. They also reported a correlation between increasing metatarsus adductus angle and increasing hallux abductus angle.[4] La Reaux and Lee reported there being 3.7 times more likely chance of developing hallux abducto valgus with metatarsus adductus deformity.[22] More recently, Ferrari and Malone-Lee found an increased metatarsus adductus angle prevalence of 55% of patients with hallux abducto valgus and only a 19% prevalence in patients with a structurally normal foot type.[14]

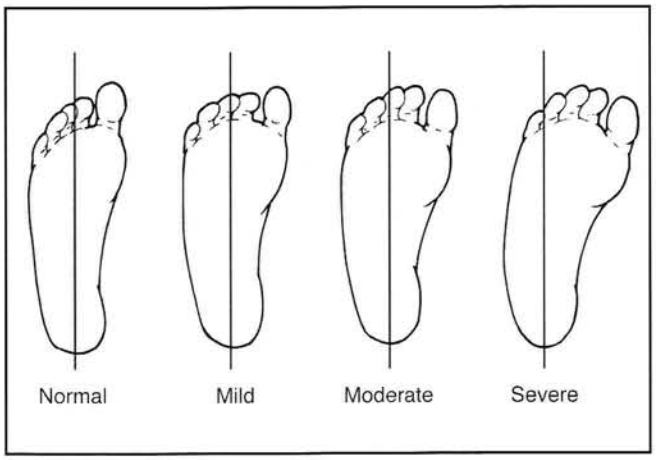

Figure 2.

As stated previously the authors acknowledge the recent works of Theodoru and Saxena and the apparent relationship between metatarsus adductus and stress related injuries to the lateral forefoot. The intent of this project is to evaluate consecutive patients with acute fracture to the proximal fifth metatarsal and to identify any relationship with metatarsus adductus regarding the anatomical placement of the injury.

MATERIALS AND METHODS

From January 2000 to April 2003, 108 consecutive patients were evaluated and treated for fracture of the proximal fifth metatarsal. All patients presented to the Podiatry Department at Scripps Clinic in La Jolla or Del Mar, California through direct referral from urgent and primary care departments or by self-referral.

Exclusion criteria included those individuals suffering from crush injuries or motor vehicle accidents, systemic diseases and any history of Charcot neuroarthropathy. Patients under the age of seventeen were also excluded to eliminate any confusion of fracture relating to consolidation of the styloid process apophysis. Fifteen subjects who under the age of seventeen were excluded. Three additional subjects were excluded. One due to lack of appropriate weight bearing foot radiographs and two secondary to absence of true acute fracture to the fifth metatarsal. This resulted in a total of ninety adult

subjects being included in the evaluation All patients included in the final results were seventeen years of age or older and suffered from an acute injury without prodromal symptoms.

Fractures were classified simply into two main categories. All fractures lying at the distal limit of the articulation between the fourth and fifth metatarsal bases or slightly more distal were placed into Group 1 (Similar to Stewart type 1 injuries). All fractures of the proximal fifth metatarsal from the most proximal tip of the tuberosity to the distal limit of the articulation of the fourth and fifth metatarsal bases were placed into Group 2. (Figure 3) Group 2 fractures were further sub-categorized as intra-articular (including fractures involving the fifth-cuboid articulation and the fourth and fifth metatarsal base articulation proximal to the distal limit), avulsion non-articular and comminuted fractures. All other fifth metatarsal fractures including shaft, neck and head fractures were excluded.

All 90 subjects sustained an acute fracture to the proximal fifth metatarsal related to indirect trauma. Twenty-four were male and 66 were female. Forty-one fractures occurred in the left foot while forty occurred in the right. The average age was 46.2 years (range 17-82 years). Six subjects sustained associated fractures. Four of these were of the fourth metatarsal base, one to the third and fourth metatarsal bases and one to the navicular.

All subjects underwent three view weight-bearing radiographic evaluation of the affected foot at initial visit or subsequent follow-up evaluations. Weightbearing radiographs were evaluated by one individual (LHR) with measurement of Metatarsus Adductus angle as described by Weissman on the dorsoplantar film.[37] (Figure 4).

Subjects were treated according to fracture presentation. Fractures in the metaphyseal-diaphyseal region distal to the articulation (Group 1) were treated conservatively with the recommended six to eight weeks of non-weightbearing immobilization (short leg cast). Those fractures that occurred in the tuberosity and base regions not extending distal to the articulation of the fourth and fifth metatarsal bases (Group 2) were also treated conservatively with four to six weeks of weightbearing immobilization (short leg walking cast, cam-walker boot, post-operative shoe). None of the 90 subjects underwent primary surgical repair of the fractured proximal fifth metatarsal.

Post-injury clinical evaluations were initially scheduled at three, six and twelve weeks. Patients with delayed healing rates past the twelve-week mark were then followed on and individual bases until clinical healing was achieved. In terms of this project, clinical healing (in weeks) was defined as a return to previous shoe-gear and activities of daily living without limitations and minimal to no pain.

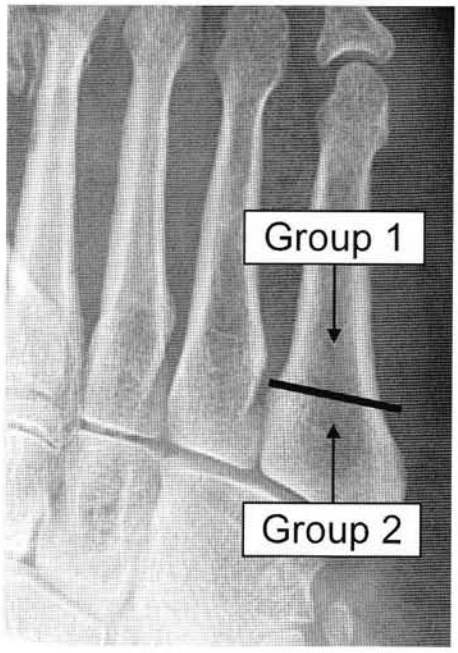

Figure 3.

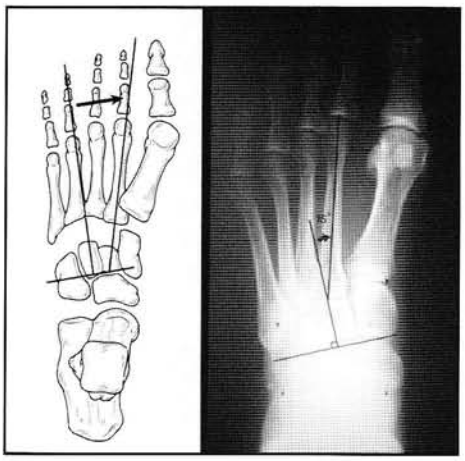

Figure 4. Metatarsus Adductus angle as described by Weissman on DP weightbearing Radiograph.

The mean values of the metatarsus adductus angle between the two groups were compared using the Welch-Unpaired t-test with statistical significance assumed at a P value <0.05. Clinical healing time in weeks was recorded for the two groups and compared again using the Welch-unpaired t-test with P values <0.05 representing statistical significance. GraphPad InStat was used to perform the statistical analysis.

Results

Of the 90 patients, nine sustained fractures distal to the articulation of the fourth and fifth metatarsals bases (Group 1), while eighty-one sustained fractures of the fifth metatarsal proximal to the distal articular limit (Group 2). The mean value of the metatarsus adductus angle for Group 1 was 24.66 +/- 2.47 (MIN 10, MAX 35) while the mean value for Group 2 was 11.78 +/- 0.54 degrees (MIN 2, MAX 24). A Welch-Unpaired t-test was performed with a statistically significant P value of <0.0001.

Sixty-six subjects (Group 1 = 6, Group 2 = 60) were followed until clinical healing was recorded. In terms of clinical healing and return to activities, the mean for Group 1 was 20.16 weeks (MIN 10 weeks, MAX 52 weeks) and the mean for Group 2 was 8.5 weeks (MIN 4 weeks, MAX 24 weeks). The Welch-unpaired t-test resulted in a P value of .1327, which was not considered statistically significant.

The mean age of Group 1 was 40.1 years while that of all Group 2 fracture subjects was 46.7 years. Of the 81 total Group 2 fractures 52 were intra-articular simple avulsion fractures, twelve were comminuted and eight were extra-articular avulsion fractures. The mean clinical healing time for Group 2 intra-articular avulsion fractures, extra-articular avulsion fractures and comminuted fractures was 8.3 weeks, 7.5 weeks and 8.8 weeks respectively with no statistical significance reported.

The mean number of total proximal fifth metatarsal fractures (Groups 1 and 2) presenting each month through the course of the three year project was 2.65 fractures per month. January, August and June presented with the most fractures at eighteen, fourteen and eleven respectively. February consistently presented with the lowest number of fractures with only three fractures total over the projects life.

DISCUSSION

Fractures of the proximal fifth metatarsal can be extremely common. Even Sir Robert Jones in the early 1900's recognized that these fractures were "very common otherwise one would not be able to meet so many cases is so short a time".[17] Over the course of three and one fourth years, the current study supports that claim that proximal fifth metatarsal fractures are common injuries with an average of 2.65 fractures presenting to the Scripps Clinic Podiatry Department each month. However, the Group 1 fractures which have demonstrated throughout the past to have a predilection for delayed/non-union and frequently associated with the eponym "Jones fracture" comprised only 10 % of the total 90 included fractures.

Confusion regarding the term "Jones Fracture" being related to a specific anatomical region has spurred some recent authors to avoid the eponym altogether.[20] Regardless of anatomical location, many authors still associate the term "Jones fracture" with delayed healing. The Group 1 fractures in the current study would not meet the criteria of "Jones fracture" according to Lawrence et al. They would be more likely classified as metaphyseal-diaphyseal fractures. Therefore, in more recent years most authors have emphasized the risk for delayed healing in these fractures distal to the fourth and fifth metatarsal base articulations. It would be beneficial to heed recent recommendations in avoiding the use of eponyms. Such practice would surely avoid confusion regarding many subjects involving the proximal fifth metatarsal fracture.

In order to avoid any confusion with the apophysis of the 5th metatarsal all subjects under the age of seventeen were excluded. The apophysis most commonly becomes visible in girls between the ages of nine and eleven years, while in boys it is commonly first visible between eleven and fourteen years.[10] Fusion of the site is usually apparent within two years. During these ages the apophysis can commonly be mistaken for a fracture. This is especially true in those individuals suffering from fifth metatarsal base apophysitis (Iselin's) which can present with pain in this area.

The mean age of those suffering from the Group 1 fractures was 40.1 years while the mean age of all Group 2 fractures was 46.2 years. The finding would support previous authors' feelings that the fractures in the metaphyseal-diaphyseal region occur frequently in younger more active subjects.[10,19] At least one subject in Group 1 (26 yrs) sustained the fracture while playing basketball. Both Zelko and Fernandez Fairen emphasized the commonality of this particular type of injury in athletes,[13,38] Fernanedez Fairen evaluated seventeen basketball players who sustained fractures of the proximal third of the shaft of the fifth metatarsal.[13] The subject in the current study who was injured while playing basketball was six feet, eight inches tall. The authors are not aware of any publication relating the height of the individual to the type of fracture that they sustain. However, there may be some relation secondary to the high number of fractures of this type sustained in basketball players. The authors recommend future investigation regarding this theory.

The current findings support the claims by Theodorou and Saxena that the metatarsus adductus foot type appears to be associated with fractures of the lateral metatarsals. However, this study more specifically relates

the metatarsus adductus foot type to an acute fracture of the fifth metatarsal just distal to the articulation between the fourth and fifth metatarsal bases. Theodorou's study must be credited for its insight. However, it was not free of limitations. Only eleven subjects were evaluated with non-weightbearing radiographs. The claim has been made that non-weightbearing films underestimate the value of the metatarsus adductus angle. In the current authors experience, non-weightbearing radiographs can actually overestimate the metatarsus adductus angle. Theodorou's report also failed to compare the metadductus foot type to normal or rectus foot types. In the current study, 90 consecutive adult patients, all with acute fractures of the proximal fifth metatarsal were evaluated with standard weightbearing radiographs. Eight of nine fractures distal to the fourth/fifth metatarsal base articulation (Group 1) had a metatarsus adductus angles greater than twenty. One of 81 subjects with fracture proximal to the fourth/fifth metatarsal base articulation (Group 2) had a metatarsus adductus angle greater than twenty.

Although the mechanism of action was not clearly defined for each subject in the current study, most subjects related the mechanism of injury to an indirect force of twisting or inversion injury to the foot. While some authors have addressed a distinct and separate mechanism of injury for both metaphyseal-diaphyseal fractures of the shaft (Group 1) and avulsion fractures of the base (Group 2),[23,26] the current authors cannot comment on the differences of mechanism between the distinct fracture sites in this series. The authors would like to suggest that the anatomical location of the fracture might not solely be related to the specific position or motion of the foot but also the specific structural foot "type". The subjects in Group 1 reported similar mechanisms of injury to those in Group 2. However, they sustained fractures in the metaphyseal-diaphyseal region of the metatarsal. The metatarsus adductus foot type may predispose these individuals to fracture in this distinct region regardless of the mechanism of action.

The treatment protocol and healing rates of the current study support those recommended by Torg, Lawrence, Quill and Landorf.[20,23,36,26] All Group 2 fractures were considered clinically healed by a mean of 9.4 weeks. All Group 2 fractures were treated conservatively with weightbearing immobilization. Of the fractures in Group 1, the mean time to healing was 20.2 weeks. One of the nine subjects in Group 1 was non-compliant in the treatment plan and was not considered clinically healed until 52 weeks after two open reductions with internal fixation. This value certainly affected the overall Group 1 healing mean and when excluding this subject the mean healing time would have been 13.8 weeks. The authors recommend individualized treatment of these fractures. Although conservative treatment was rendered and successful for the most part in our series, if the fracture is significantly displaced, a delayed/non-union or in an athlete, initial surgical considerations could be made. Only one subject in our series received open reduction and internal fixation of the fracture and this subject failed to be compliant with the conservative treatment plan.

The current study would like to acknowledge the following limitations. The authors note that although the total number of fractures evaluated was significant, the overall number of metaphyseal-diaphyseal fractures was relatively low. More investigation into the relationship of metatarsus adductus to a larger volume of proximal metaphyseal-diaphyseal fifth metatarsal fractures is warranted. In addition, it should be noted that there have been documented variations in measurement technique of the metatarsus adductus angle. The authors feel, however, that the difference in mean metatarsus adductus angle between the two groups was significant enough to eliminate evaluator error and other technique descrepancies.

CONCLUSION

Fracture of the proximal fifth metatarsal is a common injury. Those fractures proximal to the distal aspect of the fourth and fifth metatarsal articulation commonly heal with weightbearing immobilization. However, conservative treatment of those fractures of the metaphyseal-diaphyseal region distal to this articulation should include nonwieghtbearing immobilization in order to avoid delayed and possibly non-union of the bone. There appears to be a very high correlation with fractures in the proximal metaphyseal-diaphyseal region and the metatarsus adductus foot type. The metatarsus adductus foot type likely contributes to the previously reported mechanism of action and may predispose an individual to fracture in this particular anatomical region.

REFERENCES

1. Agarwal A. Jones' fracture: Texas Medicine/The Journal 1993; 89:60-1.
2. Arangio GA, Xiao D, Salathe EP. Biomechanical study of stress in the fifth metatarsal: *Clinical Biomechanics* 1997;3:160-4.
3. Banks AS, Downey MS, Martin DE, Miller SJ. McGlamary's Comprehensive Textbook of Foot and Ankle Surgery. Philadelphia; Lippincott, Williams & Wilkins. 2001; p. 915-42.
4. Banks AS, Hsu Y, Mariash, S, Zirm R. Juvenile hallux abducto valgus association with metatarsus adductus. *J Am Podiat Med. Assoc* 1994;84:219-24.
5. Bleck EE. Metatarsus adductus: classification and relationship to outcomes of treatment: *J Ped Orthop* 1983;3:2-9.
6. Bohne W. Metatarsus adductus. Bull NY Acad Med 1987;63:835-8.
7. Byrd T. Jones fracture: relearning an old injury: *S Med J* 1992;85:748-50.
8. Carp L. Fracture of the fifth metatarsal bone: *Ann Surg* 1927;86:308-20.
9. Clapper MF, O'Brien TJ, Lyons PM. Fractures of the fifth metatarsal. *Clin Orthop Rel Res* 1995;315:238-41.
10. Dameron RB. Fractures and anatomical variations of the proximal portion of the fifth metatarsal. *J Bone Joint Surg Am* 19175;57:788-92.
11. Delee JC, Evans JP, Julian J. Stress fracture of the fifth metatarsal: Am J Sports Med11983;1:349-53.
12. Farsetti P, Weinstein SL, Ponseti IV. The long-term functional and radiographic outcome of untreated and non-operatively treated metatarsus adductus: *J.Bone Joint Surg Am* 1994;76:257-65.
13. Fernandez Fairen M, Guillen, J, Busto JM, Roura J. Fractures of the fifth metatarsal in basketball players. *Knee Surg Sports Traumatol Arthrosc* 1999;7:373-7.
14. Ferrari J, Malone-Lee J. A radiographic study of the relationship between metatarsus adductus and hallux valgus. *J Foot Ankle Surg* 2003;42:9-14.
15. Green DR. Reconstructive Surgery of the Foot and Leg, Update 1998. Tucker (GA): Podiatry Institute; 1998
16. Greene WB. Metatarsus adductus and skewfoot. *Inst Course Lectures* 1994;43:161-77.
17. Jones R. Fracture of the fifth metatarsal bone by indirect violence. *Ann. Surg* 1902:35:697-700.
18. Josefsson PO, Karlsson M, Redlund-Johnell I, Wendeberg B. Closed treatment of Jones fracture: *Acta Orthop Scand* 1994;65:545-7.
19. Kavanaugh MD, Thomas BD, Mann RV. The Jones fracture revisited. *J Bone Joint Surg Am* 1978;60:776-82.
20. Landorf KB. Clarifying proximal diaphyseal fifth metatarsal fractures. *J Am Podiatric Med Assoc* 1999;89:398-404.
21. La Reaux RL, Lee BR. Metatarsus adductus and hallux abducto valgus: their correlation: *J Foot Surg* 1987;26:304-8.
22. Lawrence SJ, Botte MJ. Jones' fractures and related fractures of the proximal fifth metatarsal: *Foot Ankle* 1993;14:358-65.
23. Manoli A. Anatomical and radiological considerations of the fifth metatarsal bone. *Foot Ankle Int* 2001;24:164
24. Munro RG. Fractures of the base of the fifth metatarsal. *J Assoc Canadian Rad* 1989;40:260-1.
25. Peason JR.Combined fractures of the base of the fifth metatarsal and the lateral malleolus. *J Bone Joint Surg Am* 1961;43:513-6.
26. Quill GE. Fractures of the proximal fifth metatarsal. *Orthop Clin North Am.* 1995;26:353-41.
27. Richli WR, Rosenthal DJ. Avulsion fractures of the fifth metatarsal: experimental study of pathomechanics. *Am J Radiology* 1983;143:889-91.
28. Rosenburg GA, Sferra JJ. Treatment strategies for acute fractures and nonunions of the proximal fifth metatarsal. *J Am Acad Orthop Surg* 2000;8:332-8.
29. Saxena A, Krisdakumtorn T, Erickson S. proximal fourth metatarsal injuries in athletes: similarity to proximal fifth metatarsal injury. *Foot and Ankle Int* 2001;22:603-8.
30. Sammarco GJ. The Jones fracture. Inst Course Lect 1993;42:201-5.
31. Sgarlato T. X-ray evaluation. Comendium of Podiatric *Biomechanics.* 1971
32. Smith JW, Arnoczky SP, Hersh A. The intraosseous blood supply of the fifth metatarsal: implications for proximal fracture healing. *Foot Ankle* 1992;13:143-52.
33. Stewart IM. Jone's fracture: fracture of base of fifth metatarsal. Clin Orthop11960;6:190-8.
34. Theodorou DJ, Theodorou SJ, Boutin RD, Chung C, Fliszar E, Kakitsubata Y, Resnick D. Stress fractures of the lateral metatarsal bones in metatarsus adductus foot deformity: a previously unrecognized association. *Skeletal Radiol* 1999;28:679-84.
35. Torg JS. Fractures of the base of the fifth metatarsal distal to the tuberosity. *Orthopedics* 1990;13:731-7.
36. Torg JS, Fredrick DB, Zelko RR, Pavlov H, Peff TC, Das M. Fractures of the base of the fifth metatarsal distal to the tuberosity: *J Bone Joint Surg Am* 1984;66:209-14.
37. Weissman SD. Biomechanically acquired foot types: radiology of the foot. Baltimore;Williams & Wilkins; 1989 p. 66-90
38. Zelko RR, Torg JS, Rachun A: Proximal diaphyseal fractures of the fifth metatarsal – treatment of the fractures and their complications in athletes. *Am J Sports Med* 1979;7:95-101.