

# Inter- and Intra-Observer Differences in Proximal Fifth Metatarsal Fractures

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## ABSTRACT

**Introduction:** Proximal fifth metatarsal fractures are common. When using the Lawrence and Botte Classification for these injuries, they are classified as type 1, 2, and 3. Identifying the zone of injury is crucial to guide treatment. The authors hypothesize that inter- and intra-observer reliability of these fractures is low.

**Methods:** Anteroposterior (AP), lateral, and oblique x-rays of 60 patients with isolated fifth metatarsal base fractures were reviewed. Five physicians evaluated the radiographs and classified the fractures as type 1,2, or 3. Each of the three radiographic views were examined separately. Results were then analyzed for inter- and intra-observer reliability.

**Results:** Sixty x-rays of each of the three views were reviewed by five observers, with a total of 900 observations. Observer 1 classified all three radiographs the same at a rate of 41.67% (25/60) with Fleiss' kappa (k) 0.31; for observers 2 through 5, their rate was 63.33% (38/60), 0.573 (k), 68.33% (41/60), 0.55 (k), 58.33% (35/60), 0.55 (k), and 36.67% (22/60), 0.31 (k), respectively. For the AP view, inter-observer reliability showed 56.67% (34/60) agreement with 0.64 (k). For the oblique and lateral views, rates were 45% (27/60), 0.51 (k), and 35% (21/60), 0.44 (k), respectively. Overall, inter-observer reliability was 16.67%.

**Conclusion:** There is poor inter-observer and intra-observer reliability in the current proximal 5<sup>th</sup> metatarsal classification. This study highlights the importance of using all radiographic views and clinical history for the correct treatment. Future study should be aimed at a classification with higher reliability.

**Keywords:** Metatarsal, Bone, Classification

## INTRODUCTION

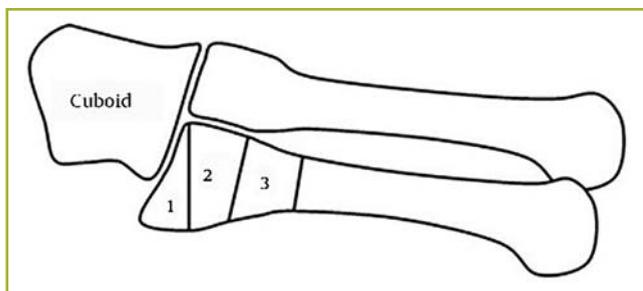
The most common type of fifth metatarsal fracture is a proximal metatarsal fracture.<sup>1</sup> Petrison et al<sup>1</sup> examined 411 metatarsal fractures and most commonly found fractures of the fifth metatarsal base. Sir Robert Jones

first defined fracture of the proximal fifth metatarsal in 1902. His description was a fracture, often caused by indirect force, in the metadiaphyseal region of the proximal fifth metatarsal.<sup>2</sup> The description is used variably, and the fracture is often identified as a "Jones fracture." Certain authors define it as a fracture at the metaphyseal-diaphyseal junction, while others describe it as a fracture at the proximal diaphysis.<sup>3</sup> It is suggested to use proper classification rather than the term "Jones fracture."<sup>3</sup>

Although many classification systems have been developed through the years, the most commonly used system was first described by Lawrence and Botte in 1993.<sup>4</sup> This system classifies fractures as type 1, 2, or 3 based on their location. Type 1 fractures describe an avulsion of the tuberosity, which may or may not involve the tarsometatarsal articulation. These fractures are typically caused during foot inversion by excess pulling of the peroneus brevis tendon or the lateral band of the plantar fascia. Type 2 fractures are described as fractures at the metaphysis-diaphysis junction that encompass the fourth-fifth intermetatarsal facet. These fractures are typically produced by forced forefoot adduction with hindfoot plantar flexion. Type 3 fractures describe proximal diaphyseal fractures that are distal to the fourth-fifth metatarsal base articulation. These are produced by excessive force to the region or chronic overloading (ie, stress fractures) (Figure 1).<sup>4</sup>

It is crucial to determine the location of the fracture because this helps guide treatment. Many physicians allow early weight bearing for type 1 injuries, but they recommend cast immobilization and non-weight bearing or possible early surgical intervention for type 2 and 3 fractures.

Avulsion tuberosity fractures (ie, zone 1 fractures) are typically managed conservatively with functional treatment and early weight bearing because the union rate and healing capacity are high and patients typically have good functional outcomes.<sup>3</sup> Weiner et al<sup>5</sup> showed



**Figure 1.** Lawrence and Botte Classification<sup>3</sup> of proximal fifth metatarsal fractures (zones 1, 2, and 3).

the effectiveness of nonoperative management of zone 1 fractures with either a soft dressing or a bulky Jones dressing. Sixty patients that had an avulsion of the proximal fifth metatarsal were examined for fracture healing and functional outcomes after being diagnosed and treated conservatively. With an average of 44 days, all patients achieved fracture union and good to excellent clinical outcome.

Zone 2 and zone 3 fractures are more prone to delayed union, non-union, and refracture. This is largely due to the anatomy of these areas, with a tenuous watershed area of blood flow in zones 2 and 3. Additionally, there are transitional forces along the fifth metatarsal, with strong ligaments anchoring the proximal bone, leaving the distal aspect mobile. For acute cases, conservative treatment with cast immobilization and non-weight bearing can be considered in less active individuals. In the athletic population, early surgical fixation with intramedullary screw is advised for faster time to union. Josefsson et al<sup>6</sup> showed that “Jones fractures” healed appropriately when treated conservatively. In their study, there were 40 patients who had fractures at the metadiaphyseal region or proximal diaphysis, and they were all treated with conservative management with immediate full weight bearing. At an average of 17-year follow-up, all fractures had healed. Seven fractures healed with delayed union or a refracture, and 39 fractures were symptom free. Fourteen of the injuries were reported to have occurred during sporting activity; however, the number of “athletes” in this study was not stated. Prolonged healing and increased nonunion rates have been document in zone 2 and 3 fractures.<sup>7</sup>

A patient’s lifestyle and activity level are also critical considerations. Zone 3 fractures, especially in athletes, are often stress fractures that are commonly problematic to heal and require more aggressive treatment. Dameron et al<sup>8</sup> showed that without surgical intervention, a zone 3 fracture may take up to 21 months to heal. Surgical fixation has shown to provide a more rapid recovery for zone 2 fractures.<sup>7</sup>

An accurate classification of the fracture is important to initiate appropriate treatment and to properly report outcomes regarding fifth metatarsal base fractures. The primary aim of this study was to determine the intra- and inter-observer reliability of the Lawrence and Botte

Classification, which is the classification system used most commonly for fifth metatarsal base fractures. The authors hypothesized that distinguishing the zone of injury on radiographs can be difficult, and that variation will exist between observers and different radiographic views in the same patient with a fifth metatarsal base fracture. Therefore, intra- and inter-observer reliability would be poor.

## METHODS

We obtained approval from our Human Research Review Committee (HRRC #19-119). Retrospective acquisition of anteroposterior (AP), lateral, and oblique radiographs of 60 patients with isolated fifth metatarsal base fractures were obtained through the radiology department of the authors’ institution. These were acquired through the radiology department system using keyword “proximal fifth metatarsal.” RM, who was not involved in classification to ensure no bias during identification, reviewed and identified the radiographs. A total of 60 patients were identified. Fractures that were not of the proximal fifth metatarsal, radiographs with any co-existing bony injuries, and pediatric radiographs with open physis were excluded. Five physicians evaluated the radiographs and classified the fractures as type 1, 2, or 3 per the classification by Lawrence and Botte. The physicians included two orthopaedic residents, one radiology resident, one orthopaedic attending, and one radiology attending. Prior to radiographic evaluation, each physician reviewed the classification of Lawrence and Botte (Figure 1<sup>3</sup>). Each radiographic view (ie, AP, lateral, and oblique) was examined separately. The physicians did not know which of the three radiographic views belonged to the same patient. Results were then compared to see the correlation between observers and between the three radiographic views of the same patient. For the purposes of this study, intra-observer reliability is the tendency for the evaluator to choose the same classification type on all three radiographic views of the same foot. Inter-observer reliability is the tendency for the five observers to choose the same classification type for a given radiograph or patient. Fleiss’ kappa was also calculated for both intra- and inter-observer reliability to further assess the statistical measure of reliability. Fleiss kappa value can be interpreted using the description in Table 5.

## RESULTS

There were 60 patients in total, each with three radiographic views of the foot. Five observers independently reviewed these radiographs for a total of 900 total observations.

There were 22 male and 28 female patients whose radiographs were reviewed, and a total of 29 left feet and 31 right feet. The average age was 42.3 years (range: 18 - 77 years). Intra- and inter-reliability were the primary outcome measures assessed. The demographics of the study are similar to those reported

in the literature. Petrisor et al<sup>1</sup> studied the epidemiology of fifth metatarsal fracture and observed over 400 fractures. The average patient age was 42 years with a majority of patients female, which was in line with this current study.

With regard to intra-observer reliability, each observer chose the same classification (type 1, 2, or 3) for all 3 radiographs. Observer one had a rate of 41.67% (25/60) with a Fleiss' kappa of 0.31, fair agreement; observer 2 had a rate of 63.33% (38/60) with a kappa

of 0.573, moderate agreement; observer 3 had a rate of 68.33% (35/60) with a kappa of 0.55, moderate agreement; observer 4 had a rate of 58.33% (22/60) with a kappa of 0.55, moderate agreement; and observer 5 had a 36.67% (22/60) with a kappa of 0.31, fair agreement (Tables 1 and 4).

There were also significant differences in regards to inter-observer reliability for each radiographic view. There was 56.67% (34/60) agreement with kappa of 0.64 on AP view, substantial agreement; 45% (27/60) agreement with kappa of 0.51 on oblique view, moderate agreement; and 35% (21/60) with kappa of 0.44 on lateral view, moderate agreement (Tables 2 and 3). Overall, inter-observer reliability was only 10 of 60 (16.67%) for agreement on classification type on all 3 radiographic views. This means that all five observers agreed on the same classification for only 10 patients of the 60 patients and 180 radiographs evaluated.

Further analysis of the data also revealed that the five observers classified one of the patient's fracture as either type 1 or type 2, which shows a large divergence in how this fracture might be classified. There were also six instances where all three different classification types (type 1, 2, and 3) were chosen for the same patient on different radiographs by an observer.

## DISCUSSION

This study demonstrates that the most commonly used classification system for fifth metatarsal base fractures has poor intra- and inter-observer reliability. Orthopaedic surgery residents, radiology residents, attending radiologists with musculoskeletal fellowship training, and an orthopaedic attending with fellowship training in foot and ankle surgery all had poor classification of these fractures.

Not only were the intra- and inter-observer reliability low, there were also instances where the difference was between zone 1 and zone 3, which greatly impacts treatment approach and presumed patient outcomes. This could mean the difference between conservative treatment for a zone 1 fracture versus strict non-weight

**Table 1. Intra-Observer Reliability**

Agreement for all 3 views (%)	
Observer 1	25 (42)
Observer 2	38 (63)
Observer 3	41 (68)
Observer 4	35 (58)
Observer 5	22 (37)

Number of times each observer chose the same classification on all three views and corresponding percentage.

**Table 2. Inter-Observer Reliability**

Radiographic View	5 / 5 Agree (%)	4 / 5 Agree (%)
Anteroposterior	34/60 (57)	52/60 (87)
Oblique	27/60 (45)	39/60(65)
Lateral	21/60 (35)	41/60(68)

Number of times all five observers agreed on each view. Then, number of times four of five observers agreed on each view.

**Table 3. Inter-Rater Agreement**

	Anteroposterior View	Oblique View	Lateral View
% Agreement	56.7	45	35
Fleiss' Kappa	0.643 (Substantial)	0.508 (Moderate)	0.441 (Moderate)
z	21.4	16.4	14
P value	0	0	0

Comparing the 5 raters, 60 subjects for each of 3 views.

**Table 4. Intra-Rater Agreement**

	Observer 1	Observer 2	Observer 3	Observer 4	Observer 5
% Agreement	47.1	63.3	68.3	58.3	36.7
Fleiss' Kappa	0.31 (Fair)	0.57 (Moderate)	0.55 (Moderate)	0.55 (Moderate)	0.31 (Fair)
z	5.25	10.2	9.41	10.2	5.49
P value	1.51x10 <sup>-7</sup>		0		3.99x10 <sup>-8</sup>
	0		0		

Comparing the three different views (computed as 3 raters, 60 subjects).

**Table 5. Kappa Values and Associated Interpretations**

Kappa	Interpretation
<0	Poor agreement
0.01 - 0.20	Slight agreement
0.21 - 0.40	Fair agreement
0.41 - 0.60	Moderate agreement
0.61 - 0.80	Substantial agreement
0.81 - 1.00	Almost perfect agreement

Table is given by Landis and Koch (1977) for interpreting  $\kappa$  values.<sup>12</sup> There is some disagreement about the validity of this scale.<sup>13</sup> The  $\kappa$ -value will be higher when there are fewer categories.<sup>14</sup>

bearing and possible early surgery for a zone 3 fracture. Improper identification of these fractures can have a considerable negative impact on healing and outcomes. Fracture location is important owing to the blood supply to the fifth metatarsal. The metaphysis is supplied by a complex system of arterioles around the non-articulating surface of the tuberosity, while the blood supply to the diaphysis is via the nutrient artery entering through the middle of the diaphysis. This creates a watershed area at the metaphysis-diaphysis junction, explaining the higher risk of delayed union and non-union of fractures in this area.<sup>9</sup>

In addition to the tenuous blood supply in the region, relatively strong ligaments attach the base of the fifth metatarsal, cuboid, and base of the fourth metatarsal. This makes the proximal most part of the fifth metatarsal relatively stable, while the diaphysis of the fifth metatarsal is quite mobile in contrast. This disparity in stability also gives rise to a propensity for delayed union and nonunion at the metaphyseal-diaphyseal junction.<sup>10</sup> DeVries et al<sup>11</sup> examined proximal fifth metatarsal fractures in 10 cadaveric specimens, specifically the anatomy and mechanics of the proximal fifth metatarsal tuberosity. The lateral band of the plantar fascia, peroneus brevis, and articular surface were identified and separated from their attachments, thereby splitting the fifth metatarsal base into zones A, B, and C. Zone A was found to be the attachment of the lateral band of the plantar fascia, zone B the attachment of the peroneus brevis, and zone C encompassed the articulation of the fifth metatarsal to the cuboid. The authors postulated that the further distal the injury was the increased likelihood of prolonged immobilization and/or internal fixation was for proper healing. Zone A was relatively stable while zones B and C were exposed to the dynamic forces of the peroneus brevis.<sup>11</sup>

There are some shortcomings of this paper. First, each radiograph was characterized individually, and not as a set of three radiographs. In real life, the physician would have all three radiographs to use in conjunction to classify the fracture and make a clinical decision. Yet this is also of utmost importance, highlighting the importance of using all views of radiographs when attempting to classify a proximal fifth metatarsal fracture; a quick classification using a single view will likely lead to improper classification and possible poor clinical outcomes. However, the overall reliability would likely increase if all three views were views simultaneously. Furthermore, in the clinical setting, the treating physician will also have a history with a mechanism of injury to aid in classification of the fracture. Additionally, with poor identification of these fractures, inappropriate treatment may be chosen leading to suboptimal clinical outcome. This study did not investigate what treatment was chosen for each radiograph or the eventual clinical outcomes of each

patient. Finally, the inclusion of residents in this study may skew the results due to their level of training and experience

Lastly, computed tomography is a common imaging modality used in foot and ankle injuries. This is especially used when there are numerous injuries through this area or high-energy trauma to help aid in exact diagnosis and surgical planning. With numerous injured structures in the foot and ankle, plain radiography becomes exceedingly difficult for exact diagnosis and CT can be very beneficial. However, in isolated proximal fifth metatarsal fractures, the risks of excessive radiation and financial costs of CT outweigh any possible benefits that would be gained. It is not the authors' recommendation to routinely use CT for evaluation of isolated proximal fifth metatarsal fractures.

Fifth metatarsal base fractures are common injuries. Understanding the anatomy and location of the fracture is crucial in determining healing potential and appropriate management. The results of this study underscore a potential risk in using a classification system for treatment guidance when there is poor inter- and intra-observer reliability. To the author's knowledge, this is the first study examining the inter and intra-observer reliability of the Lawrence and Botte Classification.

The poor intra-observer reliability showed in the paper underscores the importance of using all radiographic views, as well as clinical history, to make the best-informed assessment of a patient's injury and select the most appropriate treatment. Further study in this area should seek to establish an approach to classifying fifth metatarsal base fractures with better inter- and intra-observer reliability to assist with classification, prognostication, and treatment of our patients.

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