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Multiplanar CT Analysis of Fifth Metatarsal Morphology: Implications for Operative Management of Zone II Fractures

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Abstract

Background: Percutaneous internal fixation is currently the method of choice treating proximal zone II fifth metatarsal fractures. Complications have been reported due to poor screw placement and inadequate screw sizing. The purpose of this study was to define the morphology of the fifth metatarsal to help guide surgeons in selecting the appropriate screw size preoperatively.

Methods: Multiplanar analysis of fifth metatarsal morphology was completed using computed tomographic (CT) scans from 241 patients. Specific parameters were analyzed and defined in anteroposterior (AP), lateral, and oblique views including metatarsal length, distance from the base to apex of curvature, apex medullary canal width, apex height, and fifth metatarsal angle.

Results: The average metatarsal length in the AP view was 71.4 ± 6.1 mm and in the lateral view 70.4 ± 6.0 mm, with 95% of patients having lengths between 59.3 and 83.5 mm and 58.4 and 82.4 mm, respectively. The average canal width at the apex of curvature was 4.1 ± 0.9 mm in the AP view and 5.3 ± 1.1 mm in the lateral view, with 95% of patients having widths between 2.2 and 5.9 mm and 3.2 and 7.5 mm, respectively. Average distance from apex to base was 42.6 ± 5.8 mm in the AP and 40.4 ± 6.4 mm in the lateral views. Every measurement taken in all 3 views had a significant correlation with height.

Conclusions: When determining screw length, we believe lateral radiographs should be used since the distance from the base of the metatarsal to the apex was smaller in the lateral view. On average, the screw should be 40 mm or less to reduce risk of distraction. For screw diameter, the AP view should be used because canal shape is elliptical, and width was found to be significantly smaller in the AP view. Most canals can accommodate a 4.0- or 4.5-mm-diameter screw, and one should use the largest diameter screw possible. Larger individuals were likely to have more bowing in their metatarsal shaft, which may lead to a higher tendency to distract.

Level of Evidence: Level III, comparative series.

Keywords: proximal fifth metatarsal fracture, Jones fracture, intramedullary screw fixation, radiographic study, morphology, anatomy

Introduction

Proximal fifth metatarsal fractures are one of the more commonly diagnosed foot injuries and are particularly evident in young athletic populations.[3,10,22] Conservative treatment is typically indicated and is a successful treatment modality for tuberosity fractures (Zone I) and for patients who are less active.[3,9,12,13,19] However, studies have shown that nonoperative treatment may not produce optimal long-term outcomes and result in delayed union and return to activities for athletic patients and those with fractures in the metaphyseal diaphyseal junction (Zone II) and proximal diaphysis (Zone III).[2,3,10,18] As a result, operative intervention is recommended in highly active patient populations, with percutaneous internal fixation currently the method of choice for most surgeons treating these fractures.[1,3,10,16] Internal fixation with an intramedullary screw has the advantage of decreased healing time, accelerated mobilization, and a minimally invasive procedure.[14,15] However, this method of treatment may not always lead to predictable

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outcomes because of the poor biological environment of the proximal fifth metatarsal and the unique anatomy. The poor blood supply to the metaphyseal region of the metatarsal leads to a deficiency in fracture healing factors and may contribute to the area's tendency toward delayed union, nonunion, and refracture, even after fixation with an intramedullary screw.[6,8,23]

For percutaneous internal fixation, choosing the right screw size is also important for the healing potential of the fracture. Screw diameters and lengths are individualized for each patient to optimize fit and compression at the fracture site. However, because of the anatomy of the fifth metatarsal and the variability of its shaft morphology, choosing the right screw size can be a challenging problem for orthopedic surgeons. Most fifth metatarsals have a lateral curvature and plantar bow; intramedullary canal width can vary considerably between individuals. If a screw is too long, where the threads pass the fracture site and extend down the intramedullary canal, it can straighten the bone and produce fracture gapping, increasing the risk of delayed union or nonunion.[4,5,11,20] Also, if screw diameters are too large, this can cause diaphyseal fracture.[4,5,11]

To ensure proper screw selection and to treat proximal fifth metatarsal fractures more effectively, a better understanding of fifth metatarsal morphology may be helpful. The purpose of this study was to evaluate the morphology of the fifth metatarsal utilizing advanced multiplanar computed tomographic (CT) analysis in order to help guide surgeons in terms of selecting the appropriate screw size before entering the operating room.

Methods

Study patients were identified through a search in the institution's foot and ankle service database of patients who had received CT imaging of the foot. Inclusion criteria consisted of patients with CT imaging of the foot that included the full length of the fifth metatarsal. Patients were excluded if they had a history of metabolic bone disease, rheumatoid arthritis, or any previous skeletal injury to the fourth metatarsal, fifth metatarsal, fourth toe, or fifth toe. Between January 2010 and December 2013, a total of 241 patients received CTs of the foot and met the inclusion and exclusion criteria. Clinical charts were retrospectively reviewed, and patient age, sex, height, and weight were recorded. The recorded heights and weights were then used to calculate the BMI of each patient. Of the 241 patients who met the inclusion and exclusion criteria, 127 were men and 114 were women, with a mean age of 53.4 ± 15.2 years (range, 16-82 years). There were 206 patients who had their height recorded, with the average height being 67.5 ± 3.9 in. (range, 58.0-79.0 in.). Average height of the male population was 70.1 ± 3.3 in., whereas the average height of the female population was 65.0 ± 2.43 in.

Measurements

Each patient had their CT exam uploaded into a picture archiving and communication system (PACS) (Sectra IDS7, Sweden) in order to perform multiplanar analysis of the fifth metatarsal. Multiplanar reconstruction (MPR) was applied to each CT scan, which enabled image data to be viewed from any viewpoint and created a volume from the image stack. While in MPR mode, CTs were viewed in 3 planes: axial, coronal, and sagittal. Before images were analyzed, all 3 planes were synchronized so that they would all be viewed on the same plane in order to simulate the patient standing on a flat surface. This synchronization was done by setting the horizontal plane based on a straight line from bisecting the center of the fifth metatarsal and extending to the first metatarsal.

Specific parameters of the fifth metatarsal were analyzed and defined in anteroposterior (AP), lateral, and oblique views. In total, 12 different measurements were performed for each individual's CT scan (Table 1). Metatarsal length, distance from the apex of the metatarsal curvature to base, apex medullary canal width, apex height, and fifth metatarsal angle were measured in AP and lateral views. Apex height and fifth metatarsal angle were also measured in the oblique view (Figure 1). The apex of curvature was considered the point of maximum depth of the longitudinal arch of the metatarsal shaft. To make the oblique measurements, an oblique view needed to be created in PACS. Because all planes had previously been synchronized using MPR, rotating the plane 30 degrees in the coronal view created an oblique view in the axial viewing panel. Similar measurements were also performed on the available plain radiographs in the AP, lateral, and oblique views.

Statistics

Descriptive statistics were calculated as means and standard deviations for continuous variables and frequencies and percentages for categorical variables. The association between fifth metatarsal geometry and sex was assessed with independent samples *t* tests. Linear regression was used to assess correlations between fifth metatarsal geometry and height, canal width, and apex height. Correlations between CT scan and plain radiographic measurements were also analyzed with linear regression. All statistical analyses were performed in SAS version 9.3 (Cary, NC, USA) with a level of significance of $\alpha = 0.05$.

There were 35 patients missing height and weight information from their charts. BMI could not be calculated for these individuals, leaving a smaller population for BMI measurement (n = 206). One patient had the full metatarsal visible on the CT scan, but visibility of the metatarsal head was lightly restricted in the lateral view, preventing measurements from being taken in the lateral view. Calculations

Table 1. Fifth Metatarsal Computed Tomographic Measurements.

Measurement	Definition	Measurement Method
Anteroposterior and lateral		
1. Metatarsal length	Length from the base of fifth metatarsal to the head	Measure from the most proximal aspect of the base to the most distal aspect of the head
2. Apex to base	Length from the base of the fifth metatarsal to the apex of curvature	Measure from the most proximal aspect of the base to the apex of the curvature along the outer cortex
3. Apex medullary canal width	Width of fifth metatarsal medullary canal	Measure the distance between the 2 inner cortices of the medullary canal at the apex of curvature
4. Apex height	Height of the fifth metatarsal's apex of curvature	Draw a line from the most plantar aspect of the base to the most plantar aspect of the head. Measure the distance from the previously drawn line to the outer cortex of the apex (perpendicular to the previously drawn line).
5. Fifth metatarsal angle	Lateral deviation of the fifth metatarsal	Measure the angle created by a line bisecting the midpoint of the articular surface of the head and neck of the fifth metatarsal and line adjacent and parallel to the straightest portion of the medial outer cortex of the bone (or the dorsal aspect of the bone in the lateral view)
Oblique		
1. Apex height	(same as no. 4, above)	(same as no. 4, above)
2. Fifth metatarsal angle	(same as no. 5, above)	(same as no. 5, above)

involving measurements taken in the lateral view were carried out with a population n = 240.

Results

The average metatarsal length in the AP view was 71.4 ± 6.1, with 95% of patients having metatarsal lengths between 59.3 and 83.5 mm. In the lateral view, average metatarsal length was 70.4 ± 6.0 mm, with 95% of the patients having metatarsals between 58.4 and 82.4 mm (Figure 2). The average medullary canal width at the apex of curvature was 4.1 ± 0.9 mm in the AP view and 5.3 ± 1.1 mm in the lateral view, with 95% of patients having widths between 2.2 and 5.9 mm and 3.2 and 7.5 mm, respectively (Figure 3). For the distance from the apex of curvature to the base of the metatarsal in the AP view, patients had an average distance of 42.6 ± 5.8 mm, with 95% of patients having measurements between 31.1 and 54.1 mm. In the lateral view, patients had an average apex to base distance of 40.4 ± 6.4 mm, with 95% of patients' measurements falling between 27.5 and 53.2 mm (Figure 4).

Subgroup Analysis

Sex. Comparing fifth metatarsal morphology between males and females, males had significantly larger metatarsals than females. Metatarsal length was significantly different between groups in both the AP and lateral views ($P < .001$) and canal width was also seen to differ significantly in the lateral view ($P < .001$), with male metatarsals being longer and having larger canal diameters than female metatarsals. Males had an average metatarsal length of 74.5 ± 5.8 mm in the AP view and 73.3 ± 5.8 mm in the lateral view whereas females had an average metatarsal length of 68.0 ± 4.3 mm in the AP view and 67.1 ± 4.2 mm in the lateral view. Males had an average canal width of 5.6 ± 1.1 mm in the lateral view versus females having an average width of 5.1 ± 1.0 mm. In addition to longer metatarsals and wider canal diameters, males also had higher apices of curvature. Apex heights for males were observed to be 3.9 ± 0.9 mm, 4.2 ± 1.0 mm, and 3.0 ± 0.8 mm in the AP, lateral, and oblique views, respectively. These values can be compared to those of the female group where average apex height was observed to be lower, with heights of 3.7 ± 0.9 mm, 3.6 ± 0.8 mm, and 2.9 ± 0.7 mm in the AP, lateral, and oblique views. Males and females also differed significantly in the distance from apex to base of the metatarsal (AP and lateral view), fifth metatarsal angle (AP and oblique view), medullary canal width (lateral view), and apex height (lateral view) (Table 2).

Height. Testing for correlations of the fifth metatarsal measurements with height, it was found that every measurement taken of the fifth metatarsal in the AP, lateral, and oblique views had a significant correlation with height ($\alpha = 0.05$). Height of the individual was most closely correlated with fifth metatarsal length and distance from apex to base in both AP and lateral views ($P < .001$). For every 1-in. increase in height, fifth metatarsal length increased in the AP view by 1.0 mm and by 1.0 mm in the lateral view. Apex to base measurements also increased by 0.7 mm in the AP view and 0.7 mm in lateral view with each 1-in. increase in height. It was also found that absolute angle of the fifth metatarsal was related to height, with the height of the apex

Figure 1. A1-F2. Fifth metatarsal measurements in PACS - Metatarsal length (A1, C1), distance from metatarsal apex to base (A2, C2), apex medullary canal width (A3, C3), apex height (A4, C4), and fifth metatarsal angle (B5, D5) were measured in anteroposterior (AP) and lateral views. Apex height (E1) and fifth metatarsal angle (F2) were also measured in the oblique view.

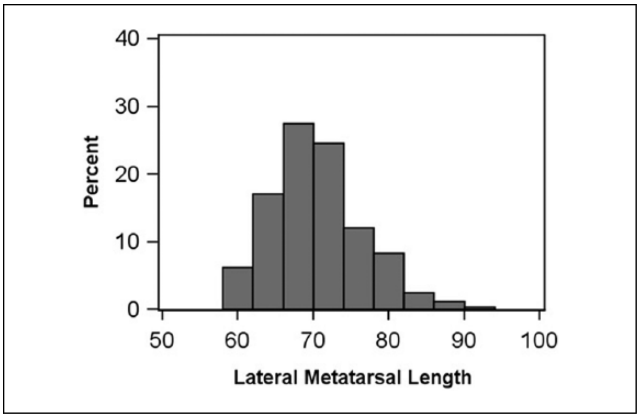

Figure 2. Distribution histogram of metatarsal length measured in the lateral view, with the line indicating the fit to a normal distribution.

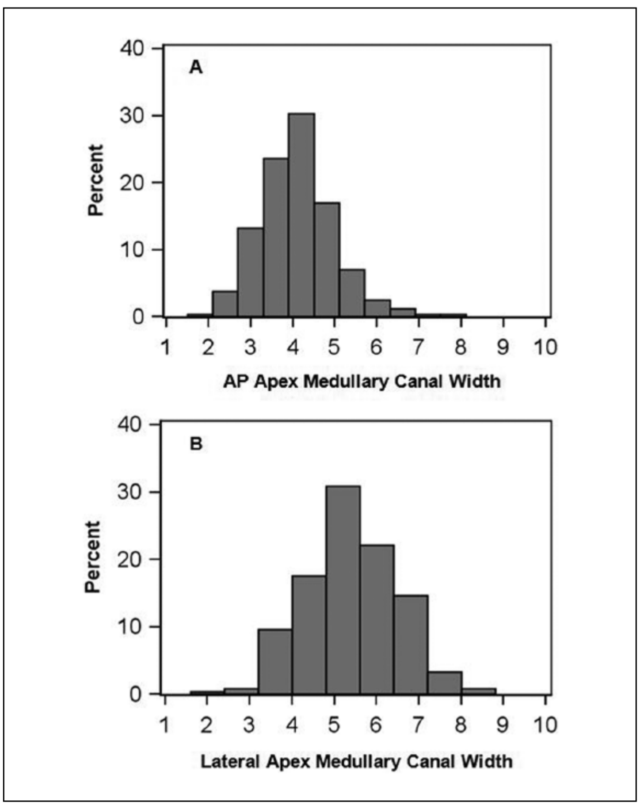

Figure 3. Distribution histogram of medullary canal width at the apex of curvature in the anteroposterior view (A) and lateral view (B), with the lines indicating the fit to a normal distribution.

of curvature increasing with increasing height and the fifth metatarsal angle decreasing with increasing height. Each 1-in. increase in height was associated with increases in apex of curvature height of 0.1, 0.1, and 0.03 mm and decreases in fifth metatarsal angle of 0.3, 0.3, and 0.2 mm in the AP, lateral, and oblique views, respectively.

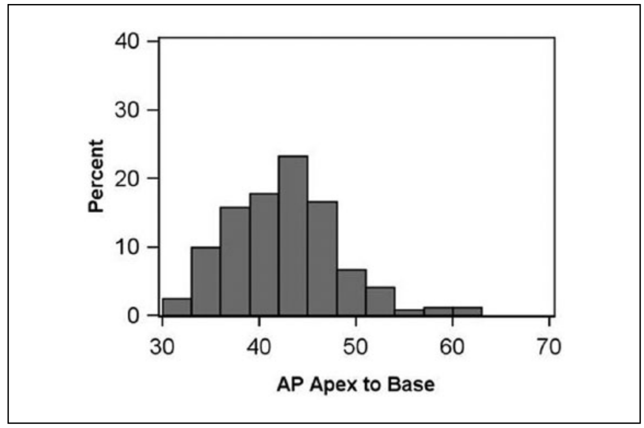

Figure 4. Distribution histogram of distance from the apex of curvature to the base of the metatarsal in the anteroposterior view, with the line indicating the fit to a normal distribution.

Canal width. Canal width was found to be significantly correlated with height, weight, and metatarsal length in both AP and lateral views, with increasing height, weight, and metatarsal length associated with increases in canal width. Canal width in the lateral view also had a significant correlation with fifth metatarsal angle in the oblique view, with increasing canal width associated with a decreasing fifth metatarsal angle. Comparing the canal width in the AP versus the lateral view, the average width in the AP view was significantly smaller (4.1 ± 0.9 mm) than the width measured in the lateral view (5.3 ± 1.1 mm) ($P < .001$). In the AP view, 95% of patients had canal widths falling between 2.2 and 5.9 mm, with 99.7% of patients having canal widths ranging from 1.3 to 6.8 mm. The lateral view had 95% of patients with canal widths between 3.2 and 7.5 mm, with 99.7% of patients between 2.1 and 8.6 mm.

Apex height. Apex height was also found to have a significant correlation with height, weight, and metatarsal length. Increasing height, weight, and metatarsal length were associated with increases in apex height in both the AP and lateral views (Table 3). Comparing apex height measurements in the AP versus lateral view, the average height in the AP view was smaller (3.8 ± 0.9 mm) than the lateral view (3.9 ± 1.0 mm), but the difference between these 2 values was not statistically significant ($P = .35$). The AP view showed that 95% of patients had apices between 31.1 and 54.1 mm, with 99.7% of patients being between 25.3 and 59.8 mm. In the lateral view, 95% of patients had apices between 27.5 and 53.2 mm whereas 99.7% of patients had apices between 21.1 and 59.7 mm.

CT Scans Versus Plain Radiographs

It was found that on average, plain radiographs tended to overestimate the fifth metatarsal measurements (Table 4). Plain radiographs overestimated metatarsal length and

Table 2. Male Versus Female Fifth Metatarsal Morphology.

Variable	Sex	n	Mean (mm)	SD (mm)	*P* Value
Anteroposterior view					
Metatarsal length	F	114	68.0	4.3	<.001
	M	127	74.5	5.8	
Apex to base	F	114	40.3	4.7	<.001
	M	127	44.6	5.9	
Apex medullary canal width	F	114	4.0	0.8	.266
	M	127	4.1	1.0	
Apex height	F	114	3.7	0.9	.098
	M	127	3.9	0.9	
Fifth metatarsal angle	F	114	7.5	4.9	<.001
	M	127	2.8	4.2	
Lateral view					
Metatarsal length	F	113	67.1	4.2	<.001
	M	127	73.3	5.8	
Apex to base	F	113	37.4	5.0	<.001
	M	127	43.0	6.5	
Apex medullary canal width	F	113	5.1	1.0	<0.001
	M	127	5.6	1.1	
Apex height	F	113	3.6	0.8	<.0001
	M	127	4.2	1.0	
Fifth metatarsal angle	F	113	8.4	4.5	<.0001
	M	127	4.5	4.7	
Oblique view					
Apex height	F	114	2.9	0.7	.483
	M	127	3.0	0.8	
Fifth metatarsal angle	F	114	3.1	4.8	<.001
	M	127	0.5	3.4	

Abbreviations: F, female; M, male; SD, standard deviation.

Table 3. Correlations With Apex Height (α = 0.05).

Dependent Variable	Independent Variable	Parameter Estimate (mm/mm)	Adjusted R^2	***P*** Value
AP apex height	Height	0.1	0.1	<.001
Lateral apex height	Height	0.1	0.1	<.001
AP apex height	Weight	<0.0	0.0	.011
Lateral apex height	Weight	<0.0	0.1	.001
AP metatarsal length	AP apex height	2.2	0.1	<.001
AP metatarsal length	Lateral apex height	1.5	0.1	<.001
Lateral metatarsal length	AP apex height	1.2	0.0	.006
Lateral metatarsal length	Lateral apex height	1.8	0.1	<.001

distance from apex to base, slightly underestimated medullary canal width, and both under- and overestimated apex height and fifth metatarsal angle, depending on the view. All measurements were found to differ significantly between CT and radiographs except for the lateral and oblique fifth metatarsal angle measurements (P = .133 and P = .438, respectively). The AP radiographs were found to most accurately approximate most CT measurements. The coefficient of determination (adjusted R^2) was higher in the AP view versus the lateral and oblique views for all measurements except for the distance from apex to base.

Discussion

A fracture occurring in Zone II of the fifth metatarsal is traditionally referred to as a *Jones fracture* and has been shown to have a tendency to develop delayed union, nonunion, or

Table 4. Computed Tomographic Parameter Correlation With X-ray Measurements.

	Mean CT (mm)	Mean X-Ray (mm)	Parameter Estimate (mm/mm)	Adjusted R^2	*P* Value
Metatarsal length					
Anteroposterior	71.4	77.3	0.7	0.8	<.001
Lateral	70.4	79.7	0.6	0.7	<.001
Distance from apex to base					
Anteroposterior	42.6	49.1	0.5	0.2	<.001
Lateral	40.4	45.0	0.5	0.3	<.001
Apex medullary canal width					
Anteroposterior	4.1	4.0	0.4	0.2	<.001
Lateral	5.3	5.0	0.3	0.2	<.001
Apex height					
Anteroposterior	3.8	3.4	0.3	0.2	<.001
Lateral	3.9	4.0	0.3	0.2	<.001
Oblique	3.0	4.0	0.1	0.1	<.001
Fifth metatarsal angle					
Anteroposterior	5.0	4.0	0.8	0.0	.002
Lateral	6.3	5.5	0.5	0.0	.133
Oblique	1.7	5.3	–0.1	<0.0	.438

refracture after initial healing.[3,10,24] It has been well documented that poor blood supply to the metaphyseal region of the proximal fifth metatarsal may lead to a deficiency in fracture healing factors, contributing to the area's tendency toward delayed union and nonunion.[21] Several studies have shown that conservative treatment may not produce optimal long-term outcomes,[2,3,10,18] so operative treatment with percutaneous internal fixation has become the method of choice in treating these difficult injuries. Although intramedullary screw fixation has generally produced good results, there are known complications, many of which have been attributed to improper selection of screw length and diameter.

The difficulty in choosing an appropriate screw length is due to the fifth metatarsal's lateral curvature and plantar bow. DeLee et al[3] individualized screw lengths for each patient, recommending the longest screw that would fit into the individual's medullary canal should be used. However, using a screw that is excessively long can perforate the medial cortex.[10] Using excessively long screws has also been shown to straighten the bone and cause gapping at the fracture site, increasing the risk of delayed and nonunion.[7,11] Delayed union, nonunion, and refracture have been associated with inadequate screw diameter as well. Many have advocated the use of 4.5-mm-diameter screws,[2,3,7,10,14,20,23] but biomechanical studies have shown increased pullout strength when larger-diameter screws are used.[6,11,23] Meanwhile, using a large-diameter screw in a medullary canal that is relatively narrow can result in diaphyseal fractures.[11]

In order to help surgeons choose the appropriate screw size before surgery and improve outcomes following percutaneous internal fixation for fifth metatarsal fractures, a better understanding of fifth metatarsal morphology could be helpful. In this study, we defined the specific anatomy of the fifth metatarsal based on CT scan data from 241 patients. The fifth metatarsal shaft had a lateroplantar curvature observed in all 3 radiographic views. In our patient population, the average distance from the base of the metatarsal to the apex of this curvature was smaller in the lateral view (average 40.4 mm) compared to the AP view (average 42.6 mm). Thus, lateral radiographs should be used when determining the desired screw length in order to avoid overestimating the length of the screw and distracting the fracture. Based on our findings, the length of the screw, on average, should be 40 mm or less.

When determining desired screw diameter, the AP view should be used because canal shape was found to be elliptical rather than circular and the width was found to be significantly smaller in the AP view (4.1 ± 0.9 mm) compared to the lateral view (5.3 ± 1.1 mm) ($P < .001$). Ninety-five percent of patients in our population had canal widths between 2.2 and 5.9 mm in the AP view and between 3.2 and 7.5 mm in the lateral view. Therefore, one should put in the largest diameter screw possible, and these numbers should be kept in mind in order to template screw diameters more accurately during preoperative planning. Although using larger screw diameters may contrast previous recommendations in the literature, our findings show that smaller-diameter screws that have traditionally been used to treat these fractures (including 4.0- and 4.5-mm screws) may be less biomechanically desirable.

A recent study by Ochenjele et al presented an anatomic description of the fifth metatarsal based on CT scan data from 119 patients.[17] They measured the metatarsal length, distance from the base of the metatarsal to the shaft curvature, and canal diameter in the coronal, sagittal, and axial planes. They found the average length from the base of the fifth metatarsal to the origin of curvature to be 52 mm. A lateroplantar curvature and elliptical canal shape were observed, similar to our study, with a larger canal diameter observed in the sagittal versus coronal plane (average coronal plane diameter of 5.0 mm). However, when measuring the distance from the base of the fifth metatarsal to the apex of curvature, the authors drew parallel lines along the inner cortices of the metatarsal from the proximal to distal shaft, ending the line and noting the apex as the point where the parallel lines came into contact with the medullary cortex. Our distance to apex length was measured from a parallel screw projectory and was stopped at the actual apex. Our method was purely anatomic while the method used by Ochenjele et al incorporated screw trajectory. The 2 methods can be viewed as complementary measurements. Using our anatomic method, we found the average distance to the apex to be lowest in the lateral view, averaging 40.4 mm, with 93% of patients having apices less than 50 mm and 54% with apices less than 40 mm. We recommend using a screw length that is short of the apex whenever possible. Therefore, based on our findings, most screws will be 40 mm or less in length and will rarely be larger than 50 mm.

Our study also further characterizes fifth metatarsal morphology based on height, weight, and BMI. We found that larger individuals had a greater degree of fifth metatarsal curvature. Increasing height, weight, and BMI were found to be associated with the absolute angle of the fifth metatarsal. As height increased, the height of the apex of curvature increased significantly and the fifth metatarsal angle decreased significantly. For every 1-in. increase in height, apex height increased significantly in the AP, lateral, and oblique views by 0.1, 0.1, and 0.03 mm, respectively ($P <$ .001, $P \leq$ .001, and $P =$ .045). In addition, the fifth metatarsal angle decreased in all 3 respective views by 0.3, 0.3, and 0.2 mm ($P =$ .006, $P =$ .006, and $P =$ .037). As the weight of patients increased, apex height remained the same but significant decreases in fifth metatarsal angle were observed, decreasing by 0.03, 0.04, and 0.02 mm in the AP, lateral, and oblique views ($P <$ .001, $P <$ .001, and $P <$ .001). Increases in BMI also demonstrated evidence of increased bowing, with apex height significantly increasing by 0.02 mm in the lateral view with every 1-point increase in BMI ($P =$ .046), and fifth metatarsal angle decreasing significantly in the AP, lateral, and oblique views by 0.2, 0.3, and 0.2 mm, respectively ($P =$ .002, $P <$ .2001, and $P =$ .001). These findings suggest that larger individuals are likely to have more bowing in their metatarsal shafts. Increased bowing of the metatarsal causes the screw to be more likely to violate the medial cortex, which may cause these individuals to have a higher tendency for fracture distraction. Thus, care must be taken when choosing an appropriate screw for these individuals in order to avoid using an excessively long screw that will perforate the medial cortex. Fifth metatarsal angle should be assessed on lateral radiographs because both distance from base to apex was found to be smallest in the lateral view (average 40.4 mm) and apex height were found to be greatest (average 3.92 mm).

A limitation of this study is the radiographic nature of the study. Though we give a detailed description of fifth metatarsal anatomy and provide guidance as to what screw types should be used to treat zone II fifth metatarsal fractures, each patient is different and screw sizes should be determined on a patient-by-patient basis using preoperative imaging. In addition, because females and males have different bone lengths, some differences with sex in the parameters tested may have been because females inherently have shorter bones than males.

In conclusion, we presented a detailed analysis of fifth metatarsal morphology and discussed the implications its unique anatomy has for surgeons trying to treat fifth metatarsal zone II fractures, or Jones fractures. Treating these fractures is a unique orthopedic problem because surgeons are trying to fit a straight screw into a curved bone that already has a poorer healing potential. The results of this study can help guide surgeons in terms of choosing the appropriate screw size preoperatively. An average screw length of 40 mm or less should be favored (depending on fracture location and orientation) to avoid going distal to the apex of curvature and potentially distracting the fracture. More than 90% of patients had apices less than this distance. The screw should be the shortest possible to get good distal purchase (partially threaded screws with 16 mm of distal threads) and, based on our findings, should rarely be larger than 50 mm and in most cases 40 mm or less. It also should be kept in mind that larger individuals are likely to have more bowing in their metatarsal shafts, which may lead to a higher tendency to distract. Appropriate screw length should be confirmed using lateral radiographs. In addition, most canals can accommodate at least a 4.0- or 4.5-mm-diameter screw, and one should use the largest-diameter screw possible as determined by AP radiographs because the AP is the shortest distance in the elliptical canal.

Declaration of Conflicting Interests

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