

## Comparison of 4.5- and 5.5-mm Cannulated Stainless Steel Screws for Fifth Metatarsal Jones Fracture Fixation

David A. Porter, MD, PhD; Rebecca Dobslaw, MS; Melissa Duncan, PA  
Indianapolis, IN

### ABSTRACT

**Background:** Complications including delayed and nonunions, and extensive time nonweightbearing with conservative treatment of fifth metatarsal Jones fractures, have led authors to recommend surgical fixation for this fracture in athletes who wish to return to activity quickly. The optimal surgical procedure, however, has not been determined. The purpose of this study was to evaluate the effectiveness of 5.5-mm cannulated screw fixation for fifth metatarsal stress fractures in athletes and compare them to an earlier cohort treated with a 4.5-mm screw. **Materials and Methods:** Twenty athletes were treated surgically with a 5.5-mm cannulated screw and postoperatively wore a removable walking boot, applied cold compression, initiated immediate range of motion, and used crutches for 1 week. Fractures were evaluated for clinical and radiographic healing. These findings were compared to a group that used 4.5-mm screws. **Results:** Average radiographic healing was 96.7% and all fractures healed clinically. Athletes returned to sports in an average of 9.3 weeks. There were three re-injuries that were treated with 2 weeks in a walking boot. No patients have required screw removal or have experienced pain at the hardware site, besides the three re-injuries. When compared to the earlier study, no differences were found. However, there were no re-fractures in the 4.5-mm study, but there were three bent screws. **Conclusion:** The current study demonstrates the clinical effectiveness of the 5.5-mm screw. However, with the numbers available, we were unable to demonstrate significant improvement over the 4.5-mm screw and thus cannot conclude that a larger screw is more effective.

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#### Corresponding Author:

David A. Porter, MD  
Methodist Sports Medicine  
The Orthopedic Specialists  
201 Pennsylvania Pkwy, Suite 325  
Indianapolis, IN 46208  
E-mail: davidporter@sbcglobal.net

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**Key Words:** Jones Metatarsal Fracture; Sports; Screw Fixation; Foot; Rehabilitation

### INTRODUCTION

Fractures located at the metaphyseal-diaphyseal junction at the base of the fifth metatarsal were first described by Sir Robert Jones in 1902.<sup>3</sup> Jones reported on four fifth-metatarsal fractures, including his own which occurred while dancing. There are several types of fifth metatarsal base fractures, each with their own preferred method of treatment. Torg et al.<sup>14</sup> classified fractures involving the proximal part of the diaphysis of the fifth metatarsal into three subtypes. Type I is an acute fracture that can be viewed radiographically with a narrow fracture line and an absence of intermedullary sclerosis. Type II is a delayed union that shows widening of the fracture line and evidence of intermedullary sclerosis on X-ray. A Type III fracture is a nonunion and displays a widened fracture line and a medullary canal completely obliterated by the sclerotic bone.<sup>2</sup>

One treatment for a Type I Jones fractures is to place the patient in a non-weightbearing cast for as long as 12 weeks.<sup>14</sup> Nonoperative treatment of this type has been shown to have an increased risk of delayed and nonunion because these fractures occur at a vascular-watershed.<sup>5,10,12,13,7</sup> Consequently, intramedullary screw fixation of Type I Jones fractures is an alternative for athletic patients who wish to return to their activities as soon as possible<sup>6</sup> and has also been recommended for patients who wish to return to work and activities of daily living more quickly.<sup>7</sup> Screw fixation is also the recommended technique for repairing Type II and Type III fractures.<sup>15</sup> DeLee et al. reported successful results with intramedullary screw fixation of the Jones fracture showing clinical healing in 3 to 6 weeks and radiographic healing in 6 to 8 weeks.<sup>1,6</sup>

For those patients who undergo screw fixation, controversy exists regarding the optimal screw type and size

needed. Pietropaoli et al. conducted a biomechanical study in cadavers comparing the 4.5-mm cannulated screw to the 4.5-mm solid, malleolar screw.<sup>8</sup> Their results indicated that either screw can be used in fixation of those fractures and that the choice of screw should be at the surgeon's discretion. Shah et al.<sup>11</sup> performed a study comparing the use of 4.5-mm partially threaded cannulated titanium screws and 5.5-mm partially threaded cannulated titanium screws in cadavers. Their results indicated that 5.5-mm screws demonstrate a statistically significant greater canal fill than 4.5-mm screws, but fixation strength was no different than the 4.5-mm screw. Kelly et al.<sup>5</sup> conducted a study comparing 6.5-mm short-threaded stainless steel screws with 5.0-mm short-threaded cannulated titanium screws in cadavers. Poor thread purchase of the medullary canal was noted with the 5.0-mm screws and excellent purchase was noted with the 6.5-mm screws. Their results indicate that larger diameter screws did not result in greater fracture stiffness, but did result in significantly greater pull-out strength. These authors<sup>5</sup> noted that a larger diameter screw may be better suited for this fracture despite no other scientific evidence for this claim.

This study evaluated the effectiveness of 5.5 mm cannulated screw fixation for fifth metatarsal stress fractures in athletes. Additionally we compared these results with a previously published study that we conducted on the use of a 4.5 mm partially threaded, cancellous, cannulated, stainless steel

screw for fixation of Jones fractures. We evaluated the advantages and disadvantages of the larger screw fixation for fifth metatarsal Jones fractures.

## MATERIALS AND METHODS

This study was approved by our Institutional Review Board. From November 1999 through June 2002, the senior author treated 79 fifth metatarsal fractures. Twenty-two of these were avulsion fractures and seven were shaft fractures that were treated non-operatively by placing the patient in a walking boot. Fifty of the 79 involved a fracture of the fifth metatarsal at the proximal part of the diaphysis just distal to the tuberosity. Patients diagnosed with this metaphyseal-diaphyseal fracture (Jones Fracture) were classified according to Torg<sup>14</sup> and given a choice of surgical intervention or non-operative treatment. Eleven patients chose non-operative treatment. Of the 39 patients who chose surgical fixation, 12 were treated with a 4.5-mm screw at the discretion of the primary surgeon because the fifth metatarsal had excessive curvature or narrowness of the canal that would not permit insertion of the 5.5-mm screw. The remaining 27 patients were treated with the 5.5-mm screw. Seven were excluded from the study as they were not athletes, leaving 20 patients that met the inclusion criteria and participated in our study (Table 1). Two subjects injured their foot at home by an inversion mechanism with the remaining 16 subjects being

**Table 1:** Demographic data

Athlete	Age	Sex	Sport	Competitive Level	Side	Injury to Surgery (days)
1	15	M	Basketball	High school varsity	R	7
2	16	F	Basketball	High school varsity	L	40
3	47	F	Aerobics	Recreational	R	12
4	48	M	Running	Recreational	R	66
5	19	M	Basketball	Recreational	R	9
6	21	M	Soccer	Collegiate division II	R	8
7	17	M	Volleyball	Recreational	R	34
8	23	M	Football	Professional	R	4
9	21	M	Track/ high jumper	Collegiate division I	R	35
10	19	F	Track	Collegiate division I	L	20
11	34	M	Soccer	Recreational	L	6
12	21	M	Lacrosse	Collegiate division I	R	75
13	35	F	Volleyball	Recreational	R	9
14	20	M	Basketball	Collegiate division I	R	1
15	16	M	Basketball	High school varsity	R	5
16	18	F	Softball	Collegiate division I	L	52
17	20	M	Football	Collegiate division I	R	4
18	24	M	Rugby	Professional	R	12
19	40	M	Basketball	Recreational	R	15
20	20	M	Football	Collegiate	L	32

injured during their athletic activity. As defined by Torg et al.<sup>14</sup>, six of the 20 Jones fractures treated with a 5.5-mm screw were acute fractures, ten were delayed unions and four were nonunions. All athletes had recurrent or persistent pain at the fifth metatarsal metaphyseal-diaphyseal junction that limited their ability to participate in sports. The mean height of the study population was 72.9 inches and mean weight was 202.4 pounds. Of the 20 patients in our study, four were initially treated non-operatively by someone other than the author. All four were placed in a boot or cast and on crutches. After several weeks, patients were referred to the author for delayed unions. All patients signed an informed consent to participate in the study.

#### Comparison group

The comparison group consisted of 23 athletes (24 fractures) that were seen by the senior author between August 1996 and December 1999 and reported in a previously published study.<sup>9</sup> These athletes were surgically treated for their Jones fracture by intermedullary screw fixation with a 4.5-mm partially threaded, cancellous, cannulated, stainless steel screw. Three of these 24 fractures were acute fractures as described by Torg et al.,<sup>14</sup> ten were delayed unions and 11 were nonunions. This group of athletes had a mean height of 72.4 inches and mean weight of 188.9 pounds.

#### Surgical technique

The surgical technique was the same for both groups with the exception of the diameter of the screw and involved use of regional anesthesia, fluoroscopic imaging for placement of the guide pin, cannulated drilling, and cannulated screw fixation. The patient was placed supine with a bump under the involved hip to position the surgical extremity in neutral rotation. The surgical leg was placed on a unilateral lithotomy leg holder under the calf (Figure 1). This arrangement gave circumferential exposure to the foot. The surgeon made a 3- to 4-cm incision proximal to the fifth metatarsal, beginning at the base and extending proximally in line with the metatarsal. The fifth metatarsal was approached inferior to the peroneus brevis. The abductor digiti minimi quinti insertion was incised in line with its fibers to expose the base of the metatarsal. A 4.5-mm cannulated screw guide pin (1.6-mm guide pin) (Synthes®, Paoli, PA) was inserted under fluoroscopy. The anatomy of the base of the fifth metatarsal is oblong and oblique going from proximal lateral to distal medial. The base is wider than the canal with more of the base lateral and plantar to the central canal. Therefore, to engage the canal centrally, we initiated our starting point medially and dorsally (high-dorsal and tight-medial). The insertion was observed in both the oblique and lateral planes. After obtaining a confirmed intramedullary position we then inserted the pin on reverse to decrease the risk of perforation of the cortex. A 3.2-mm cannulated drill from the 4.5-mm screw set was used to drill across the sclerotic intramedullary fracture portion of the fifth metatarsal. Next, the 4.5-mm drill

was used to drill the intramedullary canal and the insertion site counter sunk to insure the head of the screw was not prominent, would not fracture the base and improved the surface area for screw head compression. An appropriately length, partially-threaded, cancellous, 5.5-mm stainless steel, cannulated screw was then inserted over the guide pin to insure intramedullary placement. The longest screw that fit into the medullary canal of the individual metatarsal was selected.<sup>2</sup> The guide pin was removed after documentation of the appropriate position. Routine closure was performed.

#### Rehabilitation

Postoperative rehabilitation for patients with either the 5.5-mm and 4.5-mm intermedullary screw included immediate range of motion exercises, applying cold compression therapy, wearing a removable walking boot, and walking with crutches. A foot orthosis was used after discontinuation of the boot. Stationary bicycle aerobic fitness was initiated at the first return visit, typically three to five days after surgery. Three weeks after surgery, if the athlete had no pain ambulating or biking, he or she was allowed to wean out of the boot into a semi-rigid orthosis with an extended carbon fiber plate or steel shank, as a prophylactic measure to decrease the risk of refracture.<sup>16</sup> Choice of shoe insert was based on patient preference and availability. Patients were encouraged to continue wearing the orthosis when participating in athletics.

Stair-stepper training began when the athlete was weaned out of the boot. Running began 4 to 5 weeks postoperatively if the athlete was pain free with stair-stepper training. A functional progression program was initiated when the athlete



**Fig. 1:** Surgical setup for open reduction and internal fixation of fifth metatarsal fracture. The ability to obtain circumferential access to the foot allows radiographic visualization and an unencumbered surgical approach to the fifth metatarsal base.

was pain free with running 3 to 4 days a week, 30 minutes at a time. Return to sports was allowed when the athlete could complete a functional progression program with no pain or apprehension.

### Followup

Participants in the 5.5-mm study were followed an average of 16.5 (range, 6 to 32) months. Those in the 4.5-mm study were followed an average of 19.8 (range, 9 to 36) months. All participants completed a questionnaire regarding their activity level at the time of injury and at final followup, their time to return to sports, and any limitations or problems resulting from the surgery. Participants also completed the American Academy of Orthopaedic Surgeons' (AAOS) Lower Limb Core Module and Foot and Ankle Module at final followup. Radiographs were also obtained at final follow-up to assess the degree of bone healing and calcaneal pitch. Chart data, physical therapy data, and patient questioning were used to determine the length of time participants used crutches, were immobilized in a walking boot and used an orthosis.

Clinical healing was determined by pain score, questioning of the athletes, and by physical examination of the athlete's foot for tenderness, swelling, or deformity. Complete clinical healing was indicated by lack of symptoms with activity and lack of tenderness at the fracture site.<sup>16</sup>

Radiographic healing was determined by examination of oblique and lateral radiographs of the foot. We determined 100 percent radiographic healing to have occurred when there was no visualization of the fracture line or deformity of the fifth metatarsal, and there was visualization of an intact straight screw (Figure 2A). Figure 2B is an example of 80%

healing; and Figure 2C is an example of 60% healing, as determined by the author.

Means and standard deviations were calculated for variables including screw length, tourniquet time, time in boot, time to return to activity and followup time. For continuous variables, the Mann-Whitney U test was used to determine if there was a difference in means between the 5.5-mm group and the 4.5-mm group. Categorical variables were compared with Fisher's Exact test.

### RESULTS

The two groups were age, height, and weight matched with similar hindfoot angles, calcaneal pitch angles and no difference in Torg classification distribution (Table 2). With the numbers available no significant differences could be detected between the groups on the AAOS questionnaires, time to return to sports, or with regard to clinical or radiographic healing or calcaneal pitch angle (Table 2). However, the screw length and tourniquet time was shorter in the 5.5-mm screw study group. There was a higher rate of screw bending in the 4.5-mm group but a higher rate of bone penetration in the 5.5-mm group. However, this was not statistically significant.

Three patients in the 5.5-mm group suffered a re-injury shortly after the surgery (patients #1, 9, and 17; Table 1). In the 4.5-mm comparison group there were no re-fractures, but we did note 3 of the screws were bent at final followup. At final followup, all fractures in both groups were healed clinically. There were no reported complications. All wounds healed and there were no lasting nerve injuries. There were minor nerve sensitivities within the first month of surgery but none that affected footwear or rehabilitation and none that

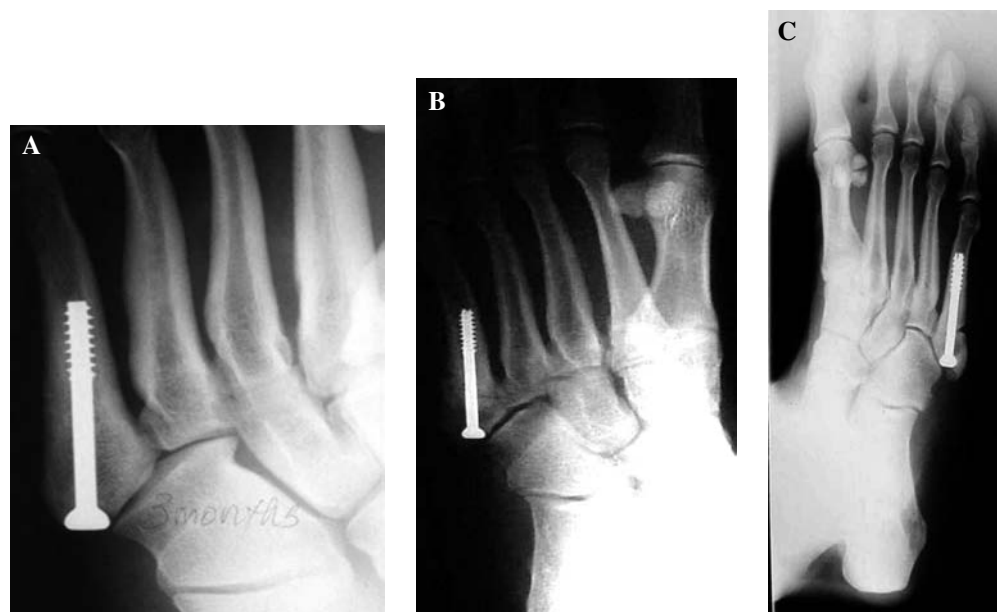


Fig. 2: Postoperative radiographs showing degree of healing: 100% healing (A), 80% healing (B), and 60% healing (C).

**Table 2:** Comparison of variables between the group who underwent surgery using the 5.5-mm screw and the group who used the 4.5-mm screw

	5.5-mm group mean (range)	4.5-mm group mean (range)
Age (years)	24.7 (15–48)	20.0 (15–28)
Height (inches)	72.9 (65–79)	72.4 (63–77)
Weight (pounds)	202.4 (125–334)	188.9 (130–230)
Screw length (mm)*	48.2 (32–60)	52.2 (42–60)
Tourniquet time (minutes)**	16.3 (6–41)	22.7 (6–44)
Time in boot (weeks)	4.2 (2–20)	4.3 (2.5–7)
Follow-up time (months)*	16.5	19.8
Foot & Ankle Pain score (out of a possible 100 points)	96.5	95.8
Lower Limb Pain score (out of a possible 100 points)	95.9	97.2
Lower Limb Function score (out of a possible 100 points)	97.4	91.8
Radiographic healing (percentage)	96.7 (80–100)	98.9 (90–100)
Screw penetration	3/20	0/24
Bent screws	0/20	3/24
Calcaneal pitch angle (degrees)	46.8 (33–58)	48.8 (37–59)
Time to return to sports (weeks)	9.3 (5–28)	7.5 (2–12)

\* indicates significant difference between the two groups at  $p \leq 0.05$

lasted longer than 1 month. To date, none of the athletes have required removal of the screw and no athlete has complained of pain at the hardware site.

## DISCUSSION

The proper method of treatment of fractures of the base of the fifth metatarsal has been a long debated topic. Screw fixation of the fracture is advised for two groups of patients: (1) the competitive high school, college, or professional athlete, especially when the injury occurs in early training; and (2) selected patients who have delayed union and recurrent fractures with nonoperative management.<sup>4</sup>

There have been several studies conducted to date on the use of intramedullary screw fixation for fifth metatarsal fractures. Kavanaugh et al.<sup>4</sup> reported a 100% union rate and no refractures for 13 patients treated with intramedullary screw fixation. DeLee et al.<sup>1</sup> also reported a 100% union rate with no complications after screw fixation in 11 athletes' fifth metatarsal fractures. DeLee et al. had a mean clinical healing time of 4.5 weeks and a mean radiographic union at 7.5 weeks.<sup>1</sup>

Wright et al.<sup>16</sup> recently reported six refractures after cannulated screw fixation of Jones fractures in athletes (screw size range, 4.0 to 5.0 mm). These six refractures occurred on the day of return to full activity despite 100% clinical and radiographic healing. The authors<sup>16</sup> recommended the use of a larger diameter screw in athletes with a larger body mass and consideration of functional bracing

in the first season of play after fixation to help prevent refracture.

Glasgow et al.<sup>2</sup> reported six failures in intramedullary screw fixation of Jones fractures, with three refractures at 3.5 to 8 months postoperatively and three delayed unions. They concluded that 4.5-mm malleolar screws should be used for fixation of fifth metatarsal Jones fractures.<sup>2</sup> However, a recent study conducted by Pietropaoli et al.<sup>8</sup> compared 4.5-mm cannulated and 4.5-mm malleolar screws for fixation of fifth metatarsal fractures. Pietropaoli et al. found no significant difference in force to initial or complete displacement, as visualized at the fracture site between the two types of screws.<sup>8</sup> The cost of cannulated versus malleolar screw fixation, however, is a consideration because the former is several times more expensive. The surgeon should decide which type of screw to use on the basis of experience, preferences for technical ease of insertion, availability, and cost considerations.<sup>8</sup>

In the current study any lack of radiographic healing (less than 100%) was entirely due to continued observation of the fracture line. There were no true nonunions at final followup and clinically there was complete healing at final followup in all athletes. Radiographically, there was complete bridging trabeculation across the fracture site but in some radiographs, the area where the fracture was located was still visualized. We therefore, in those situations, did not give the radiograph a 100% healing rate despite the lack of tenderness at the fracture site.

The mean return to sports time for the 5.5-mm study group was 9.3 weeks and for the 4.5-mm screw study was 7.5 weeks, which both compare favorably to previous studies.<sup>1,6</sup> Therefore, clinically both screws provided adequate healing to allow return to sports quickly and effectively.

Kelly et al.<sup>5</sup> believe that 4.5-mm and 5.0-mm screws may often be too small to achieve optimal fracture stabilization. Screws that are 5.5 mm may be less prone to bending than smaller diameter screws. The purpose of our study was to evaluate the effectiveness of a 5.5mm diameter stainless steel cannulated screw for fixation of fifth metatarsal Jones fractures and compare these results to our previously published study in which 4.5-mm screws were utilized. At final follow up a mean radiographic healing of 96.3% in the 5.5mm group and 98.9% in the 4.5-mm group was observed and 100% clinical healing occurred in both groups. Our mean time to return to sports in the 5.5-mm group of 9.3 weeks was slightly longer than other studies<sup>1,6,9</sup> We believe these apparent differences were due to the smaller number of athletes in the two studies. Because, with the numbers available, no significant difference could be determined between our two groups ( $p = 0.1745$ ). One reason for our increased return to sports time in the 5.5mm group would be that athlete #17 (Table 2) took 28 weeks to return to sports because he experienced a recurrent injury at initial return to sports which was 3 months postoperative. Also athlete #8 (Table 2) fell ill and had back problems that made him unable to complete his rehabilitation program for several additional weeks. After removal of these two extraneous data points, a mean average return to sports of 7.7 weeks is achieved. This more closely resembles published times for return to sports and is almost identical to our 4.5 mm data.

A previous cadaver study was conducted to compare the fixation rigidity of a 5.5-mm partially threaded cannulated titanium screw, with presumed superior endosteal purchase, to a similar 4.5-mm screw.<sup>11</sup> Their results suggested that maximizing screw diameter does not appear to be critical for fixation rigidity and theoretically risks intraoperative or postoperative fracture.<sup>11</sup> Kelly and co-workers<sup>5</sup> did however demonstrate greater pull out strength with a larger screw diameter and noted that a larger diameter screw may be better suited for this fracture. Therefore, it is still undetermined if a larger screw diameter is more beneficial.

Fixation with a stainless steel 5.5-mm cannulated intramedullary screw facilitates reliable and effective healing of fifth metatarsal stress fractures, both clinically and radiographically.

With the numbers available we detected no significant difference between the 5.5-mm and 4.5-mm study group in time to return to sports. The advantage to using a 5.5-mm screw for fifth metatarsal fixation is its superior bending strength making it less prone to bending. There were no bent screws in the 5.5-mm group, however approximately 6–8% of our 4.5-mm screws bend at some point after surgery (unpublished personal data). Screws that are larger

in diameter are harder to insert than 4.5-mm screws so there is a higher risk of perforating through the distal cortex of the fifth metatarsal. Therefore, we recommend use of the larger 5.5-mm stainless steel cannulated screw in those patients in which the fifth metatarsal canal is large enough to accommodate the wider screw. For those patients who do not have a large enough canal, a 4.5-mm stainless steel cannulated screw is recommended for fixation of the fifth metatarsal fracture since 12 of the 39 patients treated during the study period did not have a 5.5-mm screw placed because of excessive curvature or excessive narrowness in the canal.

## CONCLUSION

A 5.5-mm stainless steel cannulated screw is effective for fixation of fifth metatarsal Jones fractures in the athlete. No refractures nor screw bending occurred with this larger diameter screw. However, one can expect a higher risk of bone penetration with this larger diameter screw. The optimal screw size and type for operative fixation of fifth metatarsal Jones fractures is yet to be determined. We have undertaken a prospective study to outline the choice of a 4.5-mm versus a 5.5-mm screw.

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