Zone II and III fifth metatarsal fractures in athletes

Michael Le¹ · Robert Anderson²

Published online: 20 February 2017
© Springer Science+Business Media New York 2017

Abstract

Purpose of review This study aimed to review indications, complications, and outcomes of zone II and III fifth metatarsal fractures based on recent literature.

Recent findings High rates of nonunion, delayed union, and refracture in athletes treated non-operatively. The standard of care is operative treatment in athletes with intramedullary fixation.

Summary Operative treatment of zone II and III fractures in athletes will decrease the risk of nonunion and refracture while leading to an earlier return to play.

Keywords Metatarsal fracture · Jones fracture · Athlete

Introduction

Fractures of the proximal aspect of the fifth metatarsal were initially described by Sir Robert Jones in 1902 after he sustained the injury himself while dancing [1]. Based on epidemiological studies of the general population and athletes, proximal fifth metatarsal fractures compose approximately

70% of metatarsal fractures, especially in those with varus hindfoot malalignment [2, 3]. Fifth metatarsal fractures have been classified based on location of injury: tuberosity (zone I), metaphyseal-diaphyseal junction (zone II), or proximal diaphysis (zone III) [4]. Due to similar outcomes of zone II and zone III fractures, some authors recommend referring to both of those fracture patterns as Jones fractures and should be treated in similar fashion [5]. The biggest concerns with this injury are return to activity and high occurrence of nonunion due to the poor blood supply [6]. Anatomically, the proximal aspect of the fifth metatarsal is at risk for nonunion due to the “watershed” area located at the metaphyseal-diaphyseal junction as metaphyseal arteries enter the base and nutrient arteries enter the proximal shaft providing retrograde perfusion to the metaphyseal-diaphyseal junction [7].

Mechanism

Typically, an acute injury to the fifth metatarsal is a result of indirect force secondary to foot plantar-flexion and inversion while the base of the fifth metatarsal is tethered by significant attachments to the calcaneus by the lateral band of the plantar aponeurosis, peroneus tertius tendon to the metaphysis and the peroneus brevis to the tuberosity. Peroneus brevis tendon forces contribute to the development of the Jones fracture and create a deforming force resulting in fracture instability and possible contribution to nonunion [8]. Additionally, bony malalignment of the foot may predispose patients to fifth metatarsal fractures. Foot type varies in athletes but the two most common foot postures are supinated and under-pronated. Athletes with those two foot postures have a significant higher risk of an overuse injury [9]. Specifically, a varus hindfoot leads to increased force at the fifth metatarsal base which may lead to fracture [3]. Furthermore, patients with Jones

This article is part of the Topical Collection on *Foot and Ankle Sports Medicine*

✉ Robert Anderson
robert.anderson@orthocarolina.com

Michael Le
Michael.le2012@gmail.com

¹ Department of Orthopaedics, Carolinas Medical Center, 1000 Blythe Blvd, Charlotte, NC 28203, USA

² OrthoCarolina Foot & Ankle Institute, 2001 Vail Avenue, Suite 200B, Charlotte, NC 28207, USA

fractures are more likely to have metatarsus adductus, resulting in lateral column overload [10]. There has been recent work performed by the NFL Foot and Ankle subcommittee assessing shoe fitting in a professional football player. A significant number of these individuals were found to be wearing a shoe narrower than the foot width itself. It has been speculated that ill-fitting shoes such as these will allow the fifth metatarsal to “hang” over the last of the sole, thus increasing overload and pressures that may lead to stress-induced changes (Crandall J, personal communication, September 26, 2016).

Diagnosis

Evaluation of a patient with lateral-based foot pain should begin with a detailed history that yields answers to the following questions: Was there an acute injury? Did the patient have a history of long-standing foot pain? Was there a previous fracture? What shoes are being worn and has the individual been appropriately measured? After the history has been obtained, the provider should assess for tenderness along the fifth metatarsal and note swelling, which may be present with acute injuries. The provider should differentially diagnose any other possible injuries such as lateral ligamentous injury, peroneal tendon injury, or another type of fracture. It is also important that the provider evaluates hindfoot alignment because varus hindfoot malalignment may increase stress at the fifth metatarsal [2, 3].

Standard weight-bearing radiographs of the foot in the anteroposterior, lateral, and oblique plane should be obtained upon presentation. Plain films alone can be used to differentiate an acute fracture characterized with a well-defined fracture line as compared to sclerotic edges that indicate a nonunion. A magnetic resonance image (MRI) can be used to delineate a stress fracture if the patient is symptomatic, and hypertrophic changes are seen on radiographs. Computed tomography (CT) scans are predominantly utilized postoperatively to assess healing, and CTs are helpful in identifying a small cortical defect in the plantar-lateral aspect of the fifth metatarsal when an MRI notes edema, but the x-rays are unremarkable.

Treatment

Non-operative treatment can be attempted in lower demand patients with immobilization and non-weight bearing, but they should be informed on the high risk of nonunion up to 30% and refracture rates up to 50% [11, 6]. Therefore, operative intervention is indicated in most patients in lieu of cost of the procedure, possible hardware removal, and infection. In athletes, operative treatment is the standard to achieve union and expedite the player's return to play while reducing the risk for nonunion and refracture [12•].

In the primary setting, the gold standard technique for treating these injuries consists of fixation with an intramedullary screw. A recent cadaveric study published in 2015 determined that the average intramedullary canal diameter is 6.475 ± 1.54 mm in the plantar to dorsal plane and 4.6 ± 0.85 mm in the medial to lateral plane by digital measurement. The authors concluded that a 4.5-mm screw is the smallest diameter screw that can be efficaciously used for fifth metatarsal fractures [13•]. Another radiographic study published by Ochenjele et al. evaluated 119 patients by CT scans and determined the average coronal medullary canal diameter to be 5.0 mm at the isthmus and the length of the straight segment of the fifth metatarsal from proximal to distal to be 52 mm, approximately 68% of the metatarsal length. Based on this study, a screw greater than 4.5 mm is needed to obtain adequate purchase within the intramedullary canal while remaining shorter than 68% of the total length of the canal to prevent fracture displacement [14•]. A variety of screws may be utilized for this axial fixation of the fifth metatarsal, and there are commercially available screws specific for this indication. Our preference is a solid-headed screw that is partially threaded. We do not routinely use headless screws due to difficulty assessing length and compression, as well as potential difficulty with screw removal in the case of revision surgery.

Our technique begins with placing the patient supine on the operative table with a bump under the ipsilateral hip, and the foot itself is further elevated above the level of the contralateral foot to assist with lateral imaging. A tourniquet can be placed at the thigh or a supramalleolar esmarch tourniquet can be used to control blood loss. A mini c-arm is placed at the foot of the bed to obtain appropriate orthogonal views. After an initial surveying with a guide wire, an incision is made approximately 2 to 3 cm proximal to the fifth metatarsal approximately 1–1.5 cm in length (Fig. 1). Careful dissection through the subcutaneous tissues to the base of the fifth metatarsal will protect the peroneus brevis and the sural nerve.

Fig. 1 With the patient supine (and ipsilateral bump under the hip), use fluoroscopy to obtain orthogonal views of the foot for correct guide wire placement. Make incision 2–3 cm proximal to the base of the fifth metatarsal

Fig. 2 The guide wire is placed “high and inside” through a soft tissue sleeve while using fluoroscopy for confirmation

Surgeons are less likely to injure the lateral dorsal cutaneous branch of the sural nerve when using a percutaneous approach to fifth metatarsal fractures compared to the standard lateral approach based on cadaveric studies [15]. Utilizing a tissue sleeve for all steps described, a guide wire is placed into the dorsal and medial aspect base of the fifth metatarsal near the metatarsal-cuboid articulation. The correct position of the guide wire should be confirmed on multiple planes by fluoroscopy. The guide wire should be advanced to the fracture site but not into the medullary canal of the curved shaft so as not to penetrate the diaphyseal cortex (Figs. 2 and 3). A cannulated drill is advanced over the guide wire to the fracture site and then exchanged to a solid 3.2-mm drill that is then free-handed into the midshaft medullary canal. This maneuver

Fig. 3 The guide wire is advanced to the fracture site

Fig. 4 A cannulated drill is placed over the guide wire while protecting soft tissues with a drill sleeve

helps to insure a straight line from entry to a point distal to the fracture while avoiding cortical perforation, which may lead to a stress riser (Figs. 4, 5 and 6). The guide wire is replaced and a 4.5-mm cannulated tap is advanced across the fracture site and increased by 1-mm increments until the fifth metatarsal is adequately torqued (Fig. 7). Once the appropriate screw diameter has been determined, a selected screw is placed adjacent to the metatarsal and assessed radiographically for length (Figs. 8 and 9). Proper length insures that all threads are distal to the fracture site without extending too distal into the diaphysis as the curved shaft may displace the fracture or create a lateral gap [16]. The guide wire is removed and a solid screw is placed, typically 40 mm or longer (Figs. 10 and 11). Tighten the screw to obtain compression without penetrating or splitting the proximal metaphyseal bone. Screw retrieval in revision surgery where penetration has occurred becomes quite difficult. Fluoroscopy should be used during screw insertion to confirm screw length, competency of diaphyseal cortices, and fracture site compression. If a gap is encountered after appropriate screw selection and insertion (typically plantar-lateral), we will either inject a bone marrow aspirate concentrate mixed with a demineralized bone

Fig. 5 The cannulated still is advanced over the guide to the fracture site

Fig. 6 The cannulated drill is exchanged for a solid drill to avoid cortical penetration

graft substitute or place autogenous cancellous bone graft. The wound is closed with 3–0 nylon interrupted sutures followed by short leg splint.

The splint is removed after 1 week but patients should remain non-weight bearing for 2 weeks postoperatively and then transition to full weight bearing in a short walker boot. These CAM walker boots significantly reduce contact pressure at the fifth metatarsal base with ambulation compared to postoperative shoe and running shoes [17]. Athletes can advance to running shoes by 4–6 weeks. As evidence for radiographic bony bridging may be significantly delayed, we allow advancement of activity when the patient is able to weight bear without pain and perform multiple single limb heel rise

Fig. 7 The guide wire is placed into the medullary canal, and the cannulated tap is advanced across the fracture site and increased by 1-mm increments until adequate torque is obtained

Fig. 8 After the diameter of the screw has been determined, place the screw next to the metatarsal to select the appropriate length. All screw threads should cross the fracture site without excessive distal extension into the diaphysis to prevent fracture site distraction

and hop. Cross training with non-impact activity is initiated early and includes stationary bike, suspended pool running, and resisted tendon strengthening. The gradual return to sport-specific training includes shoes of appropriate width and modified with full-length custom orthosis to provide shock absorption and arch support. A lateral flare or hindfoot post is used in athletes with a cavovarus foot posture [3]. The metatarsal may be further protected from excessive stress during this time frame with either a clamshell orthosis or turf toe plate. Most athletes return to play between 8 and 10 weeks postoperatively, and the use of this modified shoe wear is

Fig. 9 Remove the guide wire and place the solid screw

Fig. 10 Confirm appropriate screw placement with multiple fluoroscopic images

Fig. 11 Make certain that there is no impingement on the cuboid as well

recommended for this first year, if not the duration of their sport career.

Revision surgery for nonunion or refracture presents additional, technical challenges. The iliac crest is prepped and draped for bone graft acquisition. Hardware removal may be performed through the previous percutaneous incision. If the screw is broken, a broken screw removal set must be employed to remove the screw fragment distal to the refracture or nonunion site. The nonunion/refracture site is localized using fluoroscopy, and an incision is made along the metatarsal. While protecting the sural nerve, the periosteum is elevated plantarly and dorsally. A window in the cortex may be needed to remove a distal broken screw fragment. The nonunion site is thoroughly debrided with curets, rongeurs, and osteotomes. K-wires or drill bits are utilized to perforate all exposed bone surfaces. The intramedullary canal may be sclerotic and may require removal either openly or with the initial drill to minimize distal cortical penetration or displacement. Cancellous autograft obtained from the iliac crest is packed around the nonunion site, and it can be packed into the medullary canal before screw placement. Our preference is to avoid graft harvesting from weight-bearing bone in athletes (calcaneus, tibia) for risk of stress fracture. A screw is then placed with all threads across the nonunion site or even longer if a cortical window was created for hardware removal. In rare instances of proximal bone loss or comminution, a plate may be utilized and is best positioned along the plantar aspect of the fifth metatarsal.

Following revision surgery for a nonunion or refracture, the postoperative protocol is more conservative than a primary surgery with non-weight bearing status maintained for

4 weeks, potentially longer if excessive bone is removed during broken screw retrieval. Patients are then advanced to weight bearing in a short walker boot and transitioned to running shoes with an orthosis once the patient is asymptomatic and radiographic healing is present, often at 10–12 weeks. A CT is helpful to determine and confirm union. Patients are gradually advanced to running activity, first in a pool or on an antigravity treadmill followed by eventual sport-specific activities.

Bone stimulators present another option during the recovery period. There is evidence that bone stimulators improve healing of nonunions and delayed unions [18]. With regard to Jones fractures, Holmes reported that all nine patients with delayed unions and nonunions achieved complete bony union with non-operative management using a pulsed electromagnetic field [19]. More recently, Streit et al. published a randomized clinical trial of patients with delayed unions or nonunions of the fifth metatarsal treated with intramedullary screw fixation with or without (control group) pulsed electromagnetic fields (PEMFs) had complete radiographic union 6 weeks sooner than controls did. Furthermore, those treated with PEMF had significantly higher amounts of placental growth factor (a member of the VEGF subfamily) and higher levels of brain-derived neurotrophic factor (BDNF). Both of these growth factors promote angiogenesis and vasculogenesis, therefore increasing oxygenation and nutrient delivery to the fracture site to promote healing. BMP 5 and BMP 7 expression was also increased with PEMF, and BMPs are known to play a role in fracture union [20••].

We routinely check vitamin D and calcium levels and supplement patient with deficient levels. Multiple studies have

shown vitamin D deficiency can occur in athletes, and supplementation can decrease the rate of stress fractures [21–23].

Outcomes

The overall treatment goals for fifth metatarsal fractures are successful healing and return to play. A systematic review of 26 studies published in 2013 found that fractures treated non-operatively had a 76% union rate compared to a 96% union rate following operative treatment. Furthermore, the authors found delayed unions healed 44% with non-operative care and 97% with operative treatment and nonunions had a 97% union rate with intramedullary screw fixation [11]. Another systematic review published in 2011 evaluated six studies of 330 patients, operative fixation with intramedullary screw fixation results in faster time to union, faster return to play with fewer complications compared to non-operative management [24].

Next, the evidence comparing outcomes of different screw types varies. Our institution retrospectively compared the outcomes of treatment using indication-specific screws to traditional screws in 47 patients. Both groups achieved a union rate greater than 95% with similar visual analog pain and satisfaction scores; however, the traditional screws had a significantly higher complication rate (four complications to none) [25•]. Other authors report excellent results using headless compression screws for the treatment of Jones fractures with a 3.3% failure rate [26]. A biomechanical study published in 2012 compared traditional partially threaded screws to variable pitch screws. In simulated cadaveric Jones fracture models, the partially threaded screw generated more fracture site compression and less fracture site angulation; however, there was no difference in fracture stiffness [27]. Other studies have shown no difference in bending stiffness between variable pitch screws and partially threaded screws [28]. Another treatment option for fifth metatarsal fractures includes low profile hook plates. Using simulated cadaveric Jones fractures, Huh et al. compared intramedullary screws with the low profile plate. Biomechanically, the intramedullary screw resulted in greater bending stiffness, less fracture site angulation, and greater initial torsional stiffness compared to the hook plate [29].

While operative fixation of zone II and zone III fractures have a high union rate with fixation, nonunions and refractures still occur. Hunt et al. reported a 100% union rate with return to preinjury competition level in 21 athletes at an average of 12.3 weeks. However, one patient had a subsequent refracture following a traumatic injury. All patients underwent intramedullary screw fixation with autogenous iliac crest, demineralized bone matrix and bone-marrow aspirate, or nothing [12•]. Bigsby et al. reported on outcomes of 117 fifth

metatarsal fractures, 55 of those being zone II and III injuries. Patients' Foot Function Index (FFI) scores improved from 22 at 1 month to 0 at 1 year. Also at 1 year, 28% of patients with zone I fractures and 33% with zone III continued to report pain, but none of the zone II patients reported any functional limitations and 10% of zone III patients report functional limitations [30].

Athletes desiring to return to play following a fifth metatarsal fracture should have realistic expectations. In a recent retrospective study of professional athletes, 85% of basketball players were able to return to preinjury level of function. In this study, 92% of the patients were treated operatively, 12% required reoperation, and 19% had a recurrent injury [31]. National Football League (NFL) players are also at risk for sustaining a Jones fracture due to the repetitive strain placed on the fifth metatarsal. NFL players with Jones fractures treated with intramedullary screw fixation and iliac crest bone-marrow aspirate with demineralized bone matrix injected at the fracture site were retrospectively reviewed. Postoperatively, the athletes underwent an aggressive rehabilitation program and 100% of the athletes returned to play at an average of 8.7 weeks. Refracture occurred in 12% of athletes and all returned to professional play after revision surgery [32•].

Conclusion

In high-level athletes, non-operative management of zone II and zone III fractures may prolong return to play due to high rates of delayed union, refracture, and nonunion. Therefore, we recommend operative fixation with a partial threaded intramedullary screw to obtain compression and provide inherent support. The screw threads should extend just distal to the fracture site with a typical screw length of 40 mm or greater. Furthermore, the screw size should be greater than 4.5 mm, ideally 5.0 to 6.5 mm in diameter. It remains in question whether return to play should be delayed until complete radiographic union has been obtained to decrease the risk of refracture or nonunion. Lastly, it is felt necessary for the individual to be asymptomatic with activity and in appropriated sized shoes with protective modifications.

Compliance with ethical standards

Conflict of interest Robert Anderson reports consultant fees from Wright Medical, Arthrex, Amniox, DJO, and Zimmer Biomet, as well as royalties from Arthrex, Wright Medical, and Zimmer Biomet, outside of the submitted work.

Michael Le declares that he has no conflict of interest.

Human and animal rights and informed consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:

- Of importance
- Of major importance

1. Jones RI. Fracture of the base of the fifth metatarsal bone by indirect violence. *Ann Surg.* 1902;35(6):697–700.2.
2. Petrisor BA, Ekrol I, Court-Brown C. The epidemiology of metatarsal fractures. *Foot Ankle Int.* 2006;27(3):172–4.
3. Raikin SM, Slenker N, Ratigan B. The association of a varus hindfoot and fracture of the fifth metatarsal metaphyseal-diaphyseal junction: the Jones fracture. *Am J Sports Med.* 2008;36(7):1367–72. doi:[10.1177/0363546508314401](https://doi.org/10.1177/0363546508314401).
4. Lawrence SJ, Botte MJ. Jones' fractures and related fractures of the proximal fifth metatarsal. *Foot Ankle.* 1993;14(6):358–65.
5. Chuckpaiwong B, Queen RM, Easley ME, Nunley JA. Distinguishing Jones and Proximal diaphyseal fractures of the fifth metatarsal. *Clin Orthop Relat Res.* 2008;466(8):1966–70. doi:[10.1007/s11999-008-0222-7](https://doi.org/10.1007/s11999-008-0222-7).
6. Kavanaugh JH, Brower TD, Mann RV. The Jones fracture revisited. *JBJS.* 1978;60(6):776–82.
7. Shereff MJ, Yang QM, Kummer FJ, Frey CC, Greenidge N. Vascular anatomy of the fifth metatarsal. *Foot Ankle Int.* 1991;11(6):350–3. doi:[10.1177/1071100791011000602](https://doi.org/10.1177/1071100791011000602).
8. Morris PM, Francois AG, Marcus RE, Farrow LD. The effect of peroneus brevis tendon anatomy on the stability of fractures at the fifth metatarsal base. *Foot Ankle Int.* 2015;36(5):579–84. doi:[10.1177/1071100714565177](https://doi.org/10.1177/1071100714565177).
9. Cain LE, Nicholson LL, Adams RD, Burns J. Foot morphology and foot/ankle injury in indoor football. *J Sci Med Sport.* 2007;10(5):311–9. Epub 2006 Sept 1
10. Yoho RM, Carrington S, Dix B, Vardaxis V. The association of metatarsus adductus to the proximal fifth metatarsal Jones fracture. *J Foot Ankle Surg.* 2012;51(6):739–42. doi:[10.1053/j.jfas.2012.08.008](https://doi.org/10.1053/j.jfas.2012.08.008).
11. Roche AJ, Calder JD. Treatment and return to sport following a Jones fracture of the fifth metatarsal: a systematic review. *Knee Surg Sports Traumatol Arthrosc.* 2013;21(6):1307–15. doi:[10.1007/s00167-012-2138-8](https://doi.org/10.1007/s00167-012-2138-8).
- 12.• Hunt KJ, Anderson RB. Treatment of Jones fracture nonunions and refractures in elite athlete: outcomes of intramedullary screw fixation with bone grafting. *Am J Sports Med.* 2011;39(9):1948–54. doi:[10.1177/0363546511408868](https://doi.org/10.1177/0363546511408868). **Recently published paper reviewing the outcome of elite athletes' Jones fracture union and return to play following fracture fixation**
- 13.• Scott RT, Hyer CF, DeMill SL. Screw fixation diameter for fifth metatarsal Jones fracture: a cadaveric study. *J Foot Ankle Surg.* 2015;54(2):227–9. doi:[10.1053/j.jfas.2014.11.010](https://doi.org/10.1053/j.jfas.2014.11.010). **Recent cadaveric study determining the minimal screw diameter for Jones fracture fixation**
- 14.• Ochenjele G, Ho B, Switaj PJ, Fuchs D, Goyal N, Kadakia AR. Radiographic study of the fifth metatarsal for optimal intramedullary screw fixation of Jones fracture. *Foot Ankle Int.* 2015;36(3):293–301. doi:[10.1177/1071100714553467](https://doi.org/10.1177/1071100714553467). **Recent cadaveric study also determining the minimal screw diameter for Jones fracture fixation and estimating the screw length to prevent fracture displacement**
15. Fansa AM, Smyth NA, Murawski CD, Kennedy JG. The lateral dorsal cutaneous branch of the sural nerve: clinical importance of the surgical approach to proximal fifth metatarsal fracture fixation. *Am J Sports Med.* 2012;40(8):1895–8. doi:[10.1177/0363546512448320](https://doi.org/10.1177/0363546512448320).
16. Horst F, Gilber BJ, Glisson RR, Nunly JA. Torque resistance after fixation of Jones fractures with intramedullary screws. *Foot Ankle Int.* 2004;25(12):914–9. doi:[10.1177/107110070402501212](https://doi.org/10.1177/107110070402501212).
17. Hunt KJ, Goeb Y, Esparza R, Malone M, Shultz R, Matheson G. Site-specific loading at the fifth metatarsal base in rehabilitative devices: implications for Jones fracture treatment. *PM R.* 2014;6(11):1022–9. doi:[10.1016/j.pmrj.2014.05.011](https://doi.org/10.1016/j.pmrj.2014.05.011).
18. Bassett CA, Michell SN, Gaston SR. Pulsed electromagnetic field treatment in ununited fractures and failed arthrodesis. *JAMA.* 1982;247(5):623–8.
19. Holmes Jr GB. Treatment of delayed unions and nonunions of the proximal fifth metatarsal with pulsed electromagnetic fields. *Foot Ankle Int.* 1994;15(10):552–6.
- 20.•• Streit A, Watson BC, Granata JD, Philbin TM, Lin HN, O'Connor JP, Lin S. Effect on clinical outcome and growth factor synthesis with adjunctive use of pulsed electromagnetic fields for fifth metatarsal nonunion fracture: a double-blind randomized study. *Foot Ankle Int.* 2016; doi:[10.1177/1071100716652621](https://doi.org/10.1177/1071100716652621). **Recent randomized controlled trial assessing the outcomes when using PEMF following Jones fractures and the effects of PEMF on growth factor production at the fracture site**
21. Constantini NW, Arieli R, Chodick G, Dubnov-Raz G. High prevalence of vitamin D insufficiency in athletes and dancers. *Clin J Sport Med.* 2010;20(5):368–71.
22. Lovell G. Vitamin D status of females in an elite gymnastics program. *Clin J Sport Med.* 2008;18(2):159–61.
23. Lappe J, Cullen D, Haynatzki G, Recker R, Ahlf R, Thompson K. Calcium and vitamin d supplementation decreases incidence of stress fractures in female navy recruits. *J Bone Miner Res.* 2008;23(5):741–9. doi:[10.1359/jbmr.080102](https://doi.org/10.1359/jbmr.080102).
24. Smith TO, Clark A, Hing CB. Interventions for treating proximal fifth metatarsal fractures in adults: a meta-analysis of the current evidence-base. *Foot Ankle Surg.* 2011;17(4):300–7. doi:[10.1016/j.fas.2010.12.005](https://doi.org/10.1016/j.fas.2010.12.005).
- 25.• Metzl J, Olson K, Davis WH, Jones C, Cohen B, Anderson R. A clinical and radiographic comparison of two hardware systems used to treat Jones fracture of the fifth metatarsal. *Foot Ankle Int.* 2013;34(7):956–61. doi:[10.1177/1071100713483100](https://doi.org/10.1177/1071100713483100). **Recently published study comparing fracture specific screws to traditional screws. Both screws have similar union rates but more complications are seen with traditional screws.**
26. Nagao M, Saita Y, Kameda S, Seto H, Sadatsuki R, Takazawa Y, Yoshimura M, Aoba Y, Ikeda H, Kaneko K, Nozawa M, Kim SG. Headless compression screw fixation of Jones fractures: an outcome study in Japanese athletes. *Am J Sports Med.* 2012;40(11):2578–82. doi:[10.1177/0363546512459460](https://doi.org/10.1177/0363546512459460).

27. Orr JD, Glisson RR, Nunley JA. Jones fracture fixation: a biomechanical comparison of partially threaded screws versus tapered variable pitch screws. *Am J Sports Med.* 2012;40(3):691–8. doi:[10.1177/0363546511428870](https://doi.org/10.1177/0363546511428870).
28. Sides SD, Fetter NL, Glisson R, Nunley JA. Bending stiffness and pull-out strength of tapered, variable pitch screws, and 6.5-mm cancellous screws in acute Jones fractures. *Foot Ankle Int.* 2006;27(10):821–5.
29. Huh J, Glisson RR, Matsumoto T, Easley ME. Biomechanical comparison of intramedullary screw versus low-profile plate fixation of a Jones fracture. *Foot Ankle Int.* 2016;37(4):411–8. doi:[10.1177/1071100715619678](https://doi.org/10.1177/1071100715619678).
30. Bigsby E, Halliday R, Middleton RG, Case R, Harries W. Functional outcome of fifth metatarsal fractures. *Injury.* 2014;45(12):2009–12. doi:[10.1016/j.injury.2014.06.010](https://doi.org/10.1016/j.injury.2014.06.010).
31. Begly JP, Guss M, Ramme AJ, Karia R, Meislin RJ. Return to play and performance after Jones fracture in the National Basketball Association Athletes. *Spots Health.* 2016 Jul;8(4):342–6. doi:[10.1177/1941738115621011](https://doi.org/10.1177/1941738115621011).
32. Lareau CR, Hsu AR, Anderson RB. Return to play in National Football League Players after Operative Jones Fracture Treatment. *Foot Ankle Int.* 2016;37(1):8–16. doi:[10.1177/1071100715603983](https://doi.org/10.1177/1071100715603983). **Most recent paper reviewing the outcomes of Jones fracture in NFL players and the amount of time required for return to play**