Don't Forget to Evaluate the Ankle—Tips and Tricks for Operative Treatment of Distal Third Tibia Fractures

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Introduction

Tibial shaft fractures are commonly managed with open reduction and internal fixation (ORIF) using an intramedullary nail (IMN). Tibia Fractures are the most common open fracture with approximately 24% of tibial diaphysis fractures being open.[1] Intramedullary nailing provides excellent rates of union in cases of open tibial shaft fractures.[2] In addition, reamed intramedullary nails have lower rates of reoperation compared to unreamed tibial nails.[3]

Combined tibia and fibula fractures usually occur after high energy mechanisms such as motor vehicle accidents.[4] There are numerous considerations for operative versus non-operative management of fibula fractures in patients with a concomitant tibia fracture. Surgeons who favor fixation may cite improved ability to restore tibial length, alignment, and rotation. Those favoring non-operative management of associated fibula fractures cite its possibility to decrease cyclic loading of the tibial fracture site, thereby risking delayed union or nonunion.[5]

Distal third tibia shaft fractures may be associated with occult posterior malleolus fractures in about 30% of patients that may be displaced iatrogenically during IMN of the tibia shaft fracture.[6] As such, it is vital to identify associated posterior malleolus fractures to prevent further articular surface damage during ORIF. As a matter of practice, our institution orders advanced imaging in the form a CT scan for any distal third tibia fracture to assess for this highly associated injury as it may affect surgical decision-making.

The posterior malleolus and syndesmosis are connected via the posteroinferior tibiofibular ligament (PITFL). Fixing posterior malleolus fractures and fibular fractures can confer stability to the syndesmosis which may obviate the need to surgically fix the syndesmosis.[7]

In cases of syndesmotic instability, transyndesmotic fixation can be achieved using suture buttons, screws, or a combination of the two constructs.[8] This is typically performed after the other fractured components are addressed. The syndesmotic integrity is then determined after a stress exam as to whether it needs to be stabilized surgically.

The selected staging of multiple different surgical steps is important with the increasing complexity of fractures. We present the case of a patient with an open distal third tibia fracture, posterior malleolus fracture, distal fibula fracture, and an additional unstable syndesmosis after a motorcycle collision. The sequence of fixation as well as meticulous wound closure are of importance in this case. A successful surgical outcome requires a thorough preoperative plan so that each step assists with creating of an overall appropriate construct to stabilize the injury—and in the case of an open fracture—also prevent infection.

Case Presentation

The patient is a 31-year-old male who presented with a Gustilo-Anderson Type 3A (GA3) open left distal-third spiral tibia and fibula fracture. The patient was temporized in the trauma bay, the wound was washed with saline and betadine and he was placed into a splint. Antibiotics (Ceftriaxone for GA3 injuries) and tetanus were administered upon arrival. Advanced imaging was obtained which revealed an intra-articular extension of the tibial shaft fracture with a posterior malleolus fracture (Figure 1,2). The patient was admitted and administered standing antibiotics. His injured leg was elevated on a ramp and serial compartment checks were performed.

Surgical Technique

Given the concern for his soft tissue envelope, he underwent surgical debridement and irrigation and temporizing external fixation of the left leg one day after presentation. The traumatic wound was extended both proximally and distally at the apices. A The fractured ends of the tibia were exposed and debrided. Any loose fragments of diaphyseal bone and debris were removed. The wound was then irrigated with 6 liters of normal saline. The deep tissue was closed

Figure 1. Initial patient evaluation in the trauma bay showing an open tibia fracture with bone extruding through the skin.

with Vicryl. The skin was closed primarily with #3-0 nylon in an Allgöwer-Donati fashion. The external fixator was then applied. One Schanz pin was placed trans-calcaneal and one in the proximal tibia in an anterior to posterior direction. The delta frame was then constructed, the tibia fracture and trimalleolar ankle fracture was closed reduced, and the construct was locked. An out of plane pin in the tibia was placed to enhance the multiplanar construct.

Six days after his injury, definitive fixation was performed. The patient was positioned supine on a radiolucent table with a hip bump. The operative leg was elevated on a leg ramp to aid with intraoperative fluoroscopic acquisition. The left leg was prepped and draped. The fibula was first addressed. The external fixator remained in place to help maintain fibular length. An incision was made over the distal tip of the fibula after identification of an appropriate starting point was identified on both AP and lateral fluoroscopic images. A 3.5 mm drill hole was made at the tip of the fibula followed by a 2.5 mm drill bit to ream the canal distally. A humeral guidewire was inserted into the entry site created in the fibula distally (Figure 3). Next, an incision was made over the fibular shaft fracture. A small lobster clamp was used to manipulate and reduce the fracture fragments (Figure 4). After reduction, the humeral

Figure 3. Intraoperative mortise x-ray of the ankle showing humeral guidewire insertion into the distal aspect of the fibula.

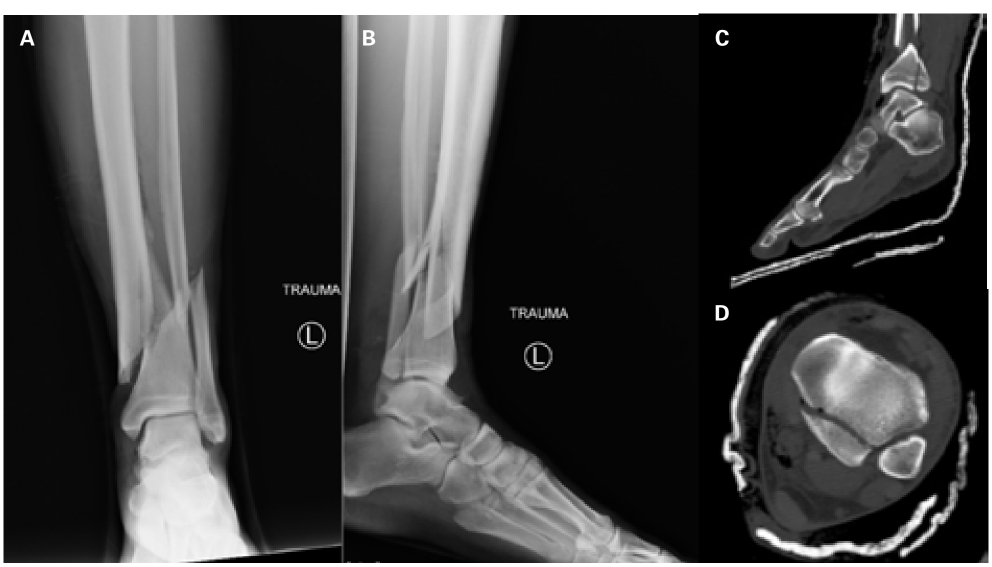

Figure 2. (A) Anteroposterior and **(B)** lateral radiographs of the left distal tibia showing spiral distal third tibia and fibula fractures and posterior malleolus fracture; **(C)** Sagittal and **(D)** axial CT slices further characterizing the non-displaced posterior malleolus fracture.

Figure 4. Intraoperative fluoroscopy image of the left distal tibia/fibula showing reduction of the fibula fracture with a lobster claw reduction clamp. Humeral guide wire has now been passed proximal to the fracture site in the fibula.

guidewire was advance just short of the fibular head, thereby stabilizing the fibular shaft fracture. The fibular guide wire was then cut and advanced so the entire wire could be buried within the fibula to avoid prominence.

With the fibula now stabilized, the posterior malleolus was addressed. Percutaneous incisions were made over the distal tibia followed by blunt dissection down to the level of the tibial plafond. This technique was selected to protect the anterior compartment tendons and neurovascular structures. The posterior malleolus was fixed by inserting two screws via a lag by technique approach to compress the posterior malleolus. This was done by drilling the outer diameter (3.5mm) of the screw up to the fracture site. The drill was then switched to a 2.5mm drill bit to match the inner diameter of the screw. This was drilled through the far cortex. A depth gauge was inserted to measure appropriate length screw. A 3.5mm fully threaded screw with a washer was then placed at the level of the plafond. This step was repeated for a second plafond screw (Figure 5). Because of the nondisplaced nature of this fracture, no reduction aids were required. As there was now adequate reduction/compression of the articular surface, the last fracture to be addressed was the tibial shaft.

The 17-centimeter traumatic wound on the medial side of the shin was opened. The fracture site was debrided a second time and all loose bone fragments were removed followed by irrigation with six liters of normal saline. Aided by the fixation achieved of the fibula fracture, a pointed reduction clamp was then used to reduce the tibial shaft through the open traumatic wound (Figure 6). AP and

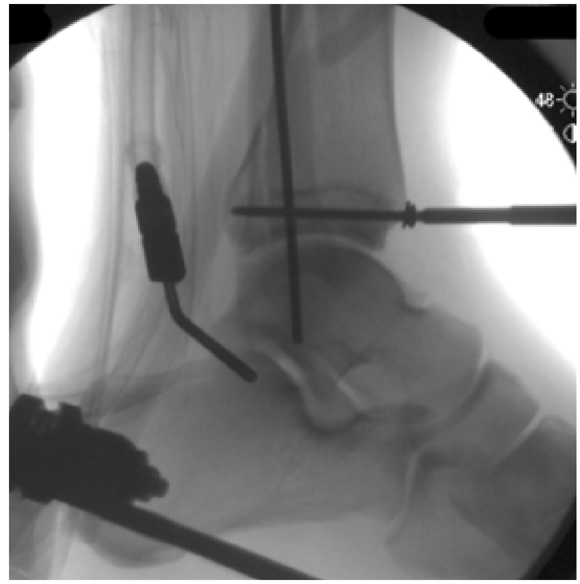

Figure 5. Intraoperative fluoroscopy of the lateral distal tibia demonstrating posterior malleolus fracture fixation via placement of anterior to posterior lag screw with washer.

Figure 6. Intraoperative fluoroscopy of the tibia/fibula demonstrating use of reduction clamps to reduce the tibial shaft fracture.

lateral fluoroscopic images confirmed length, alignment, and rotation of the distal third tibia fracture. The external fixator tibial pins were then removed along with the bars attached to them. The calcaneal pin was left in place to pull traction if needed. The surgical team next moved to placement of a tibial nail.

The suprapatellar approach was used to gain access to the patellofemoral joint with a small incision starting a fingerbreadth above the superior pole of the patella centered over the quadriceps tendon. After dissection to the paratenon, medial and lateral edges of the quadriceps tendon were identified and the quadriceps tendon was incised to bone sharply. The patellofemoral guide was placed into the knee. A drill tip wire was placed in the ideal starting point for an IMN on both the AP and lateral views: just medial to the lateral tibial spine and on the anterior lip of the tibial plateau.

On a lateral radiograph, the proximal tibia was reamed with utilizing fluoroscopy to confirm the posterior tibial cortex was not violated. A ball-tipped guidewire was inserted down the canal, past the fracture site which remained appropriately reduced, to the physeal scar. Sequential reaming was performed up to a size 11mm reamer. A 10mm nail was inserted over the ball-tipped guidewire. The ball-tipped guidewire was removed, and the intramedullary nail was stabilized with two screws proximally using the external targeting guide and two screws distally using the perfect circles technique. The temporizing clamp was then removed. The calcaneal Schanz pin was removed as well.

Due to the high energy mechanism of injury, the syndesmosis was assessed with an external rotation stress examination of the ankle. An appropriate mortise radiograph was obtained and with external rotation stress, syndesmotic instability was noted. As a result, while manually squeezing the tibia and fibula to maintain the syndesmotic relationship, a single 3.5mm quadricortical transyndesmotic screw was placed across the fibula and tibia to stabilize the syndesmosis (Figure 7).

All the wounds were thoroughly irrigated with saline. Vancomycin powder was then administered over the site of the prior open fracture. The regular surgical incisions were closed in staged fashion as is standard practice. The skin layer was closed with Allgöwer-Donati stitches utilizing #3-0 nylon. The patient was splinted and made non-weightbearing. Postoperative x-rays were obtained (Figure 8). The patient was admitted, with compartment checks for 24 hours after surgery, 24 hours of antibiotics, and made non-weight-bearing in a splint for both soft tissue rest and given the intra-articular and syndesmotic injuries.

Figure 8. Immediate postoperative radiographs showing a restoration of tibia/fibula length alignment and rotation with the tibia IMN, fibular nail, plafond screws, and a transyndesmotic screw. **(A)** AP of proximal tibia/fibula; **(B)** AP of distal tibia/ fibula; **(C)** Lateral of proximal tibia/fibula; **(D)** Lateral of distal tibia/fibula.

Figure 7. Intraoperative fluoroscopy of the tibia/fibula demonstrating placement of a quadricortical transyndesmotic screw across the distal tibia/fibula.

The patient followed in clinic two weeks postoperatively from definitive fixation. He was noted to have expected healing of his fractures and skin (Figure 9, 10). The sutures over the open fracture were removed twenty-nine days after definitive fixation. At two months postop, he was allowed to weight bear as tolerated. Skin incision at that time had some areas of eschar (Figure 11).

At three months postop, he was able to return to work as a mechanic. Approximately seven months postop, radiographs revealed interval healing at his fracture site. Notably, the syndesmotic screw was found to be broken at this visit, but he denied any symptoms related to this (Figure 12). A discussion was had regarding eventual

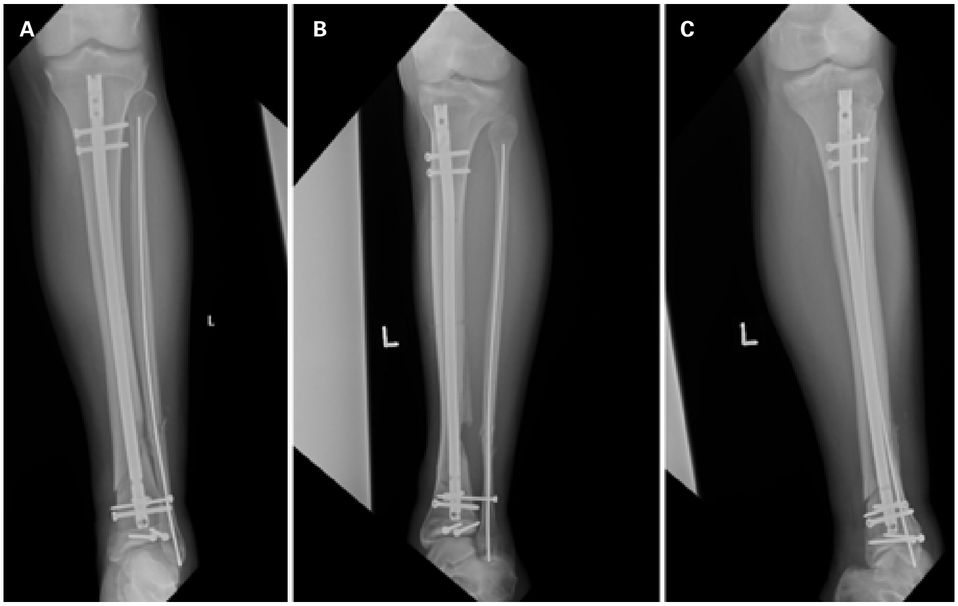

Figure 9. Anteroposterior, oblique, and lateral radiographs of the left tibia and fibula 8 weeks postoperatively demonstrating interval healing at the distal tibia and fibula fracture sites with callous formation.

Figure 10. Clinical photographs demonstrating Allgöwer-Donati sutures of the left **(A)** medial and **(B)** lateral ankle incisions 13 days postoperatively.

removal of hardware if the patient so desired. The patient had full range of motion and strength of his left lower extremity. Clinical photos at this visit are shown in Figure 13. He was discharged from the practice and instructed to follow up as needed.

Discussion

Open tibial shaft fractures are often definitively treated with IMN. Open fractures treated with IMN demonstrate excellent rates of union. Concurrent posterior malleolus fractures should be addressed prior to inserting the IMN to avoid displacing the fracture and damaging the articular surface.[6]

There is conflicting literature on whether one should fix the fibula. Some authors suggest there is no benefit, as patients who undergo ORIF exhibit similar rates of deformity, infection, and union.[5] However, other series have advocated for ORIF of the fibula to promote soft tissue healing. Fibula fixation may also assist with achieving appropriate length, alignment, and rotation of the tibia, as was the choice for surgical management with this patient.[9] Generally, methods for ORIF of the fibula include plating and nailing. The method in this case stabilizes the fibula with a small-diameter humeral guide wire, which has been shown to facilitate tibia reduction without disturbing local soft tissues.[10] The incision for fibula humeral guide wire instrumentation with another small incision over the fibular shaft fracture site is much smaller than what would be required for fibular shaft plating.

Posterior malleolus fractures are usually fixed if the fracture involves more than 25% of the articular surface. Fractures with less than two-millimeter step-off and involving less than 25% of the articular surface can be managed non-operatively.[11] Fracture fixation methods vary

Figure 11. Clinical photograph of the left medial lower leg demonstrating interval healing of the incision eight weeks postoperatively. Areas of dry eschar are noted along the incision.

depending on the fracture type. Buttress plating, posterior to anterior lag screws, and anterior to posterior lag screws are popular options for fixation in this region of the body. Buttress plating has been shown to be biomechanically superior to lag screw fixation by minimizing vertical displacement of the fracture fragment.[12] However, plating requires a more extensive soft tissue dissection and requires modification in patient positioning to expose the fracture site. Lag screws are a useful fixation strategy in nondisplaced fractures that do not require a significant reduction. Anterior to posterior lag screws also avoids having to reposition the patient for that component of the procedure.

Transyndesmotic fixation is utilized to stabilize a disrupted syndesmosis. This can be achieved with flexible fixation by way of suture buttons or more rigid fixation by way of screws. Tricortical or quadricortical fixation can be used with no apparent difference between the two options. The goal of syndesmotic fixation is to restore the tibia/fibula interval, preserve fibular length, and maintain proper alignment of the fibula in the tibial incisura.[13]

In this case, the fibula was first reduced and fixed to help with obtaining the appropriate length of the fractured tibia. The posterior malleolus was then fixed prior to instrumentation of the tibia to prevent displacement of the articular surface. Obtaining length and stability of the fibula can reduce the posterior malleolus due to the attached soft tissue. Once the tibial shaft was fixed, the syndesmosis was stressed and deemed to be injured. A screw was placed across the tibia and fibula to stabilize the syndesmosis.

Risk of deep surgical site infection needs to be considered in the setting of open fractures. In the setting of open tibia fractures, vancomycin powder use has been shown to reduce the risk of gram-positive deep surgical site infection.[14] In addition, given the increased risk of skin complications in open fractures, meticulous soft tissue handling is imperative. The use of Allgöwer-Donati suture technique during primary closure has been associated with higher rates of primary healing and decreased rates of

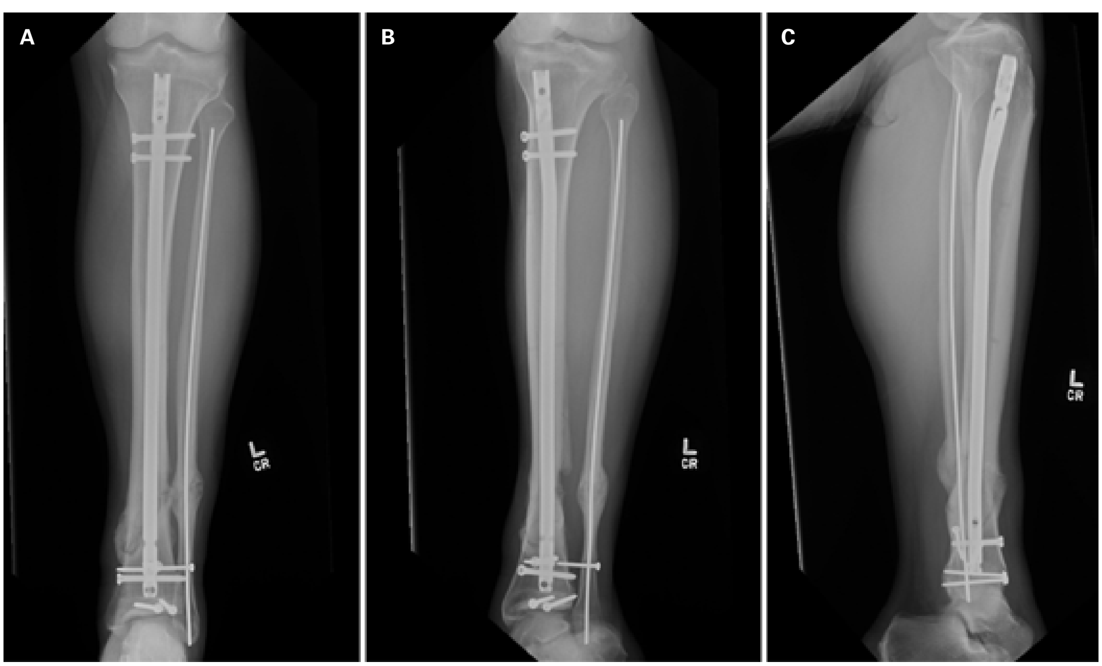

Figure 12. (A) Anteroposterior, **(B)** oblique, and **(C)** lateral radiographs of the left tibia/fibula six months postoperatively demonstrating interval healing at the distal tibia and fibula fracture sites. There is a fracture of the transyndesmotic screw noted.

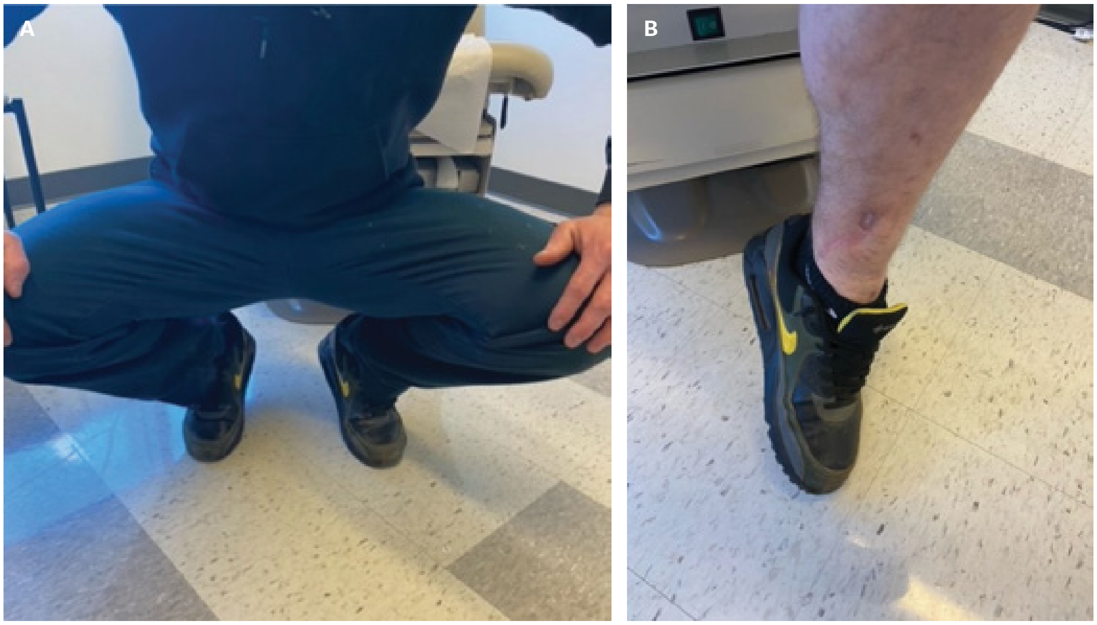

Figure 13. Clinical photographs demonstrating **(A)** a painless squat and **(B)** a healed left medial ankle incision six months postoperatively.

subsequent flap procedures.[15] The Allgöwer-Donati suture has been shown to allow for better soft tissue perfusion and less strangulation compared to the vertical mattress in a clinical trial.[16]

Conclusion

The order of fixation for each component of a complex lower extremity injury is vital when obtaining appropriate reduction and fixation. Fixation of the fibula assists with obtaining the desired length of the tibia. Fixation of the articular surface prevents additional difficulties with anatomic reduction of the articular surface before insertion of the tibia IMN. It also prevents the disruption of the articular surface during nail insertion. The syndesmosis is stressed and stabilized if needed after all other fixation is complete. Wound bed vancomycin powder helps to prevent deep surgical site infection. Lastly, skin closure using sutures in an Allgöwer-Donati fashion allows for optimal healing of complex wounds that are at high risk for complications.

References

1. Melvin JS, Dombroski DG, Torbert JT, *et al.* Open tibial shaft fractures: I. Evaluation and initial wound management. *J Am Acad Orthop Sur*g. 2010; 18(1):10-9.

2. Melvin JS, Dombroski DG, Torbert JT, *et al.* Open tibial shaft fractures: II. Definitive management and limb salvage. *J Am Acad Orthop Surg*. 2010; 18(2):108-17.

3. Prospectively Evaluate Reamed Intramedullary Nails in Patients with Tibial Fractures Investigators, Bhandari M, Guyatt G, Tornetta P, *et al.* Operatively Treated High-risk Tibia Fractures: A Randomized Clinical Trial. *JAMA Surg* 2021; 156(5):e207259. Randomized trial of reamed and unreamed intramedullary nailing of tibial shaft fractures. *J Bone Joint Surg Am*. 2008; 90(12):2567-2578.

4. Torino D, Mehta S. Fibular Fixation in Distal Tibia Fractures: Reduction Aid or Nonunion Generator?. *Journal of Orthopaedic Trauma*. 2016; 30 S22-S25.

5. Li C, Li Z, Wang Q, *et al.* The Role of Fibular Fixation in Distal Tibia-Fibula Fractures: A Meta-Analysis. *Adv Orthop*. 2021; 2021:6668467.

6. Wang Z, Chen W, Zhu Y, *et al.* Incidence and missed diagnosis risk of occult posterior malleolar fractures associated with the tibial shaft fractures: a systematic review. *J Orthop Surg Res*. 2021; 16(1):355.

7. Behery OA, Narayanan R, Konda SR, *et al.* Posterior Malleolar Fixation Reduces the Incidence of Trans-Syndesmotic Fixation in Rotational Ankle Fracture Repair. *Iowa Orthop J*. 2021; 41(1):121-125.

8. Xu Y, Kang R, Li M, *et al.* The Clinical Efficacy of Suture-Button Fixation and Trans-Syndesmotic Screw Fixation in the Treatment of Ankle Fracture Combined With Distal Tibiofibular Syndesmosis Injury: A Retrospective Study. *J Foot Ankle Surg*. 2022; 61(1):143-148.

9. Huang CW, Wu WT, Yu TC, *et al.* Retrograde Intramedullary Kirschner Wire Fixation as an Alternative for Treating Distal Fibular Shaft Fractures Combined with Distal Tibial Pilon Fractures. *J Pers Med*. 2022;12(7):1124.

10. Dombroski D, Scolaro JA, Pulos N, *et al.* Fibular fracture stabilization with a guidewire as supplementary fixation in tibia fractures. *Am J Orthop* (Belle Mead NJ). 2012; 41(11):506-9.

11. De Vries JS, Wijgman AJ, Sierevelt IN. Long-term results of ankle fractures with a posterior malleolar fragment. *J Foot Ankle Surg*. 2005; 44(3):211-217.

12. Anwar A, Zhang Z, Lv D, *et al.* Biomechanical efficacy of AP, PA lag screws and posterior plating for fixation of posterior malleolar fractures: a three dimensional finite element study. *BMC Musculoskelet Disord*. 2018;19(1):73.

13. Porter DA, Jaggers RR, Barnes AF, *et al.* Optimal management of ankle syndesmosis injuries. *Open Access J Sports Med*. 2014 Aug 5;5:173-82.

14. Major Extremity Trauma Research Consortium (METRC), O'Toole RV, Joshi M, Carlini Anthony R, *et al.* Effect of Intrawound Vancomycin Powder in Operatively Treated High-risk Tibia Fractures: A Randomized Clinical Trial. *JAMA Surg*. 2021;156(5):e207259.

15. DeBaun, Malcolm R. MD, Goodnough, L. *et al.* Type III Open Tibia Fractures Treated With Single-Stage Immediate Medullary Nailing and Attempted Primary Closure Yield Low Rates of Flap Coverage. *Journal of the American Academy of Orthopaedic Surgeons*. 2021. 31(5):p 252-257,

16. Shannon, Steven F. MD, Houdek, Matthew T. MD, Wyles, Cody C. BS, *et al.* Allgöwer–Donati Versus Vertical Mattress Suture Technique Impact on Perfusion in Ankle Fracture Surgery: A Randomized Clinical Trial Using Intraoperative Angiography. *Journal of Orthopaedic Trauma* 2017. 31(2):p 97-102