Management of a Multiply-Injured Patient with a Diaphyseal Tibial Fracture: Case Report and Technical Tips for Traveling Traction

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Introduction

Diaphyseal tibia fractures are the most common long bone fracture of which 24% are open injuries.[1] Because these injuries are associated with increased risk of wound complications and infection due to the degree of soft tissue injury, initial management is vital to set a good foundation for healing. For a variety of factors, some patients may not be clinically stable enough to undergo definitive fixation immediately. In those situations, the surgeon may employ principles of damage control orthopedics (DCO) and stabilize the fracture with external fixation and defer open reduction and internal fixation (ORIF) to a later time.[2]

Most diaphyseal tibia fractures are treated with intramedullary nailing. However, for those treated initially with external fixation, one technique is the transfixion pin distractor technique or "traveling traction" (Figure 1).[3] This external fixation provides relative stability at the fracture site by providing adequate length, alignment, and rotation. Traveling traction use began in the 1990s to help with obtaining fracture reduction prior to intramedullary nail insertion.[4] Traveling traction in the tibia is performed by placing a Schanz pin in the proximal tibia and in the distal portion of the tibia or the posterior portion calcaneus in a bicortical fashion so that the pin is accessible on both the medial and lateral sides of the limb. Both Schanz pins are clamped on either end and are connected to each other with bars placed medially and laterally. Manual reduction can be obtained and then the clamps are tightened to hold the fracture out to length. Since this external fixator is parallel to the tibia, it is easy to manage from a nursing care standpoint. Proper placement can also facilitate future instrumentation of the tibia with nailing when the Schanz pin is placed out of the way of the planned path of the nail. Once the tibia is locked proximally and distally, the external fixator can be removed. This case report describes the use of traveling traction as a temporizing measure and reduction tool with a plan for future definitive fixation.

Case Presentation

The patient is a 33-year-old-male who was brought in by police drop-off after sustaining multiple gunshot wounds (GSWs). Initial survey in the trauma bay revealed GSWs to the left upper back, right lower back, right buttock, and right groin. His overall injury burden included a left hemopneumothorax, left hemidiaphragm, high-grade renal and splenic lacerations, right femoral vein injury as well as multiple lumbar spinous process, transverse process fractures, and rib fractures. A chest tube was placed immediately upon arrival in the trauma bay, and the vascular injury required reconstruction by vascular surgery. Transfusion protocol was initiated upon arrival due to hypotension. The patient was taken to the OR emergently for cavitary triage. During the surgical procedure, he was found to have an open right tibia fracture (Figure 2). Vascular surgery performed femoral vein reconstruction. Trauma surgery

Figure 1. An example of the tibial transfixion pin distractor technique (aka 'traveling traction').

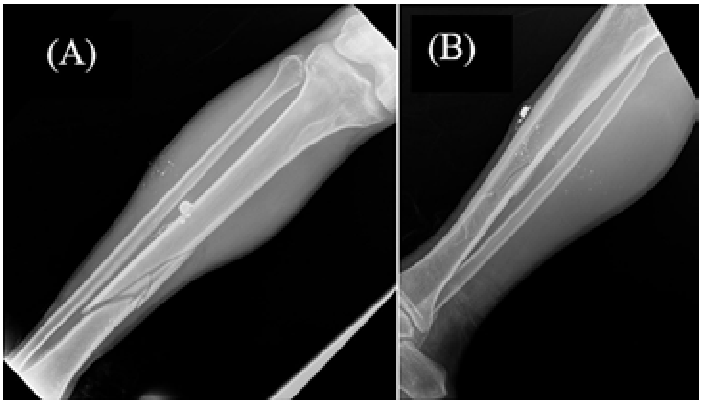

Figure 2. (A) AP and **(B)** lateral x-ray of the right tibia and fibula demonstrating a comminuted midshaft tibia fracture.

performed fasciotomies of the right lower leg. Orthopedic surgery was consulted intra-operatively for management of the open fracture. Due to the unstable nature of the patient, the decision was made to perform tibial fracture stabilization with damage control orthopedics and the utilization of traveling traction.

The Procedure

Traveling Traction

After vascular reconstruction of the femoral vein and right lower leg fasciotomies, the orthopaedic team assumed surgical care of the patient for surgical management of the tibia fracture. The right lower extremity was addressed first by irrigating the fasciotomy wounds and the open fracture site.

The procedure begins with obtaining a perfect lateral of the knee and foot to obtain an appropriate starting point for 5.0mm Schanz pin. An appropriately sized drill bit was placed medially on the posteroinferior quadrant of calcaneus under fluoroscopic guidance as described by Tornetta. A path was drilled through the near and far cortex in the axial plane from a medial to lateral trajectory. This technique allows the surgeon to minimize the risk of iatrogenic damage to the neurovascular bundle medially.[5] After this, a centrally threaded 5.0mm Schanz pin was placed so the threads were within the bony calcaneus (Figure 3). Attention was then turned to the proximal tibia. Under fluoroscopic guidance with a perfect lateral of the knee, the appropriate starting point for the proximal tibia pin was identified. This is at the lateral surface of the tibia, just anterior to the proximal aspect of the fibular head (Figure 4). A bicortical path was drilled followed by placement of a centrally threaded 5.0mm Schanz pin so the pin would be parallel to the articular surface of the tibial plateau and the pin in the calcaneus. Importantly, the proximal fixator pin is placed posterior in the tibia to allow for uninhibited placement of an intramedullary nail should that be the selected option for definitive treatment.

Next, clamps were placed on both ends of the proximal and distal Schanz pins into which two bars were placed. The clamps were placed on the inside of each pin to allow for more stable distraction. A closed reduction of the tibia was performed and the frame was locked in place. Postoperative radiographs of the external fixator were obtained (Figure 5). The fasciotomy incisions were left open. The right lower leg skin incisions were then loosely closed with staples and a vessel loop using the roman sandal technique to allow for soft tissue swelling (Figure 6). A dry dressing was applied to the overlying

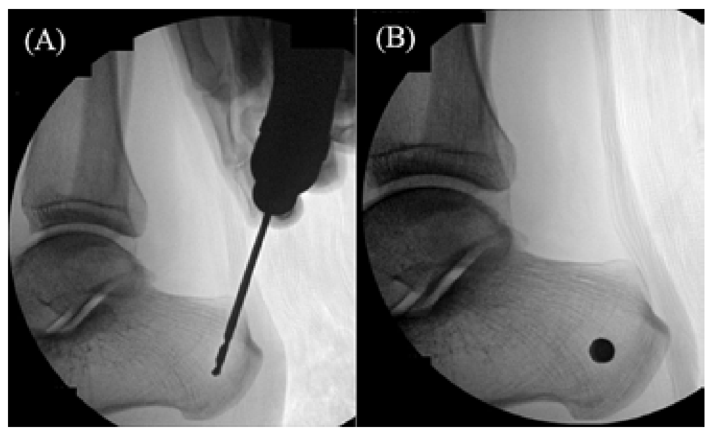

Figure 3. Intraoperative fluoroscopic imaging demonstrating **(A)** Placement of drill bit in posteroinferior quadrant of calcaneus; **(B)** Bicortical Schanz pin placed in posterior quadrant of calcaneus.

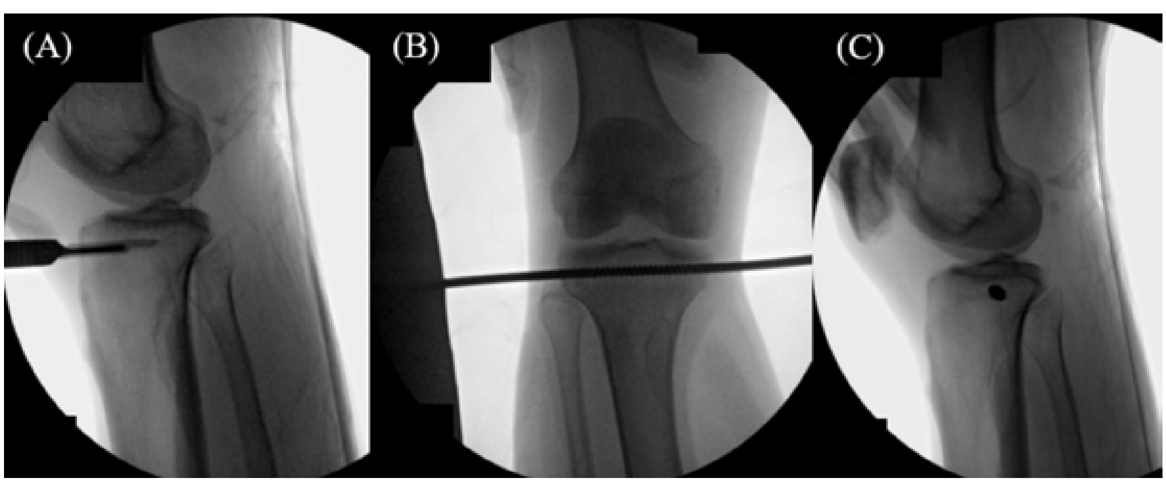

Figure 4. Intraoperative fluoroscopic imaging demonstrating **(A)** Lateral of proximal tibia localizing starting point for drill bit (just anterior to the proximal fibular head); **(B)** AP and (C) lateral of the proximal tibia showing Schanz pin placement.

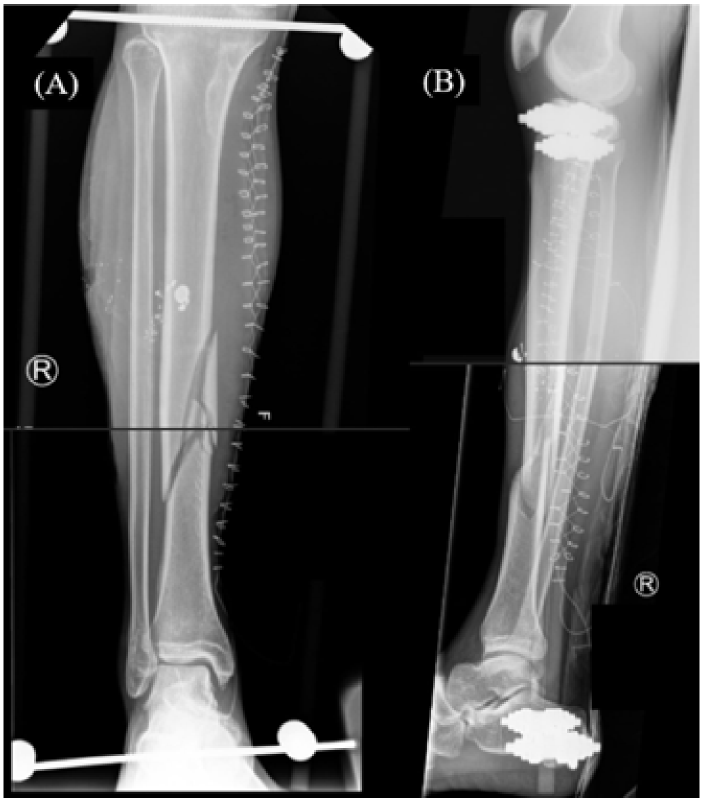

Figure 5. Postoperative **(A)** AP and **(B**) lateral radiographs of the right tibia and fibula status post application of traveling traction external fixation demonstrating adequate length, alignment, and rotation.

exposed subcutaneous tissue. The general trauma surgeon team resumed care of the patient intra-operatively. The orthopaedic plan included continuous first-generation cephalosporin antibiotics until the patient could be definitely closed.

Intramedullary Nail (IMN)

The patient was taken back to the OR for definitive fixation of his tibia. The right lower extremity was prepped and draped with the external fixator on and irrigation and debridement was performed at the fracture site. The fasciotomy wounds were evaluated, hematoma was evacuated, and any necrotic muscle was excised in all four compartments. Attention was then turned to fixing the tibia.

Our institution's preferred technique is placement of a tibial nail through a suprapatellar approach. With the patient's operative extremity on a bone foam extremity holder, a small incision proximal to the patella was utilized sharply centered over the quadriceps tendon. Under subcutaneous tissue, the medial and lateral edges of the tendon were identified following by sharp dissection centered on the tendon through bone to allow access to the knee. With a threaded guide wire, the starting point was obtained just medial to the lateral tibial spine and on the most anterior aspect of the tibial plateau. The guide wire was then taken into proximal tibia in appropriate trajectory. The proximal tibia was opened with an opening reamer and the ball-tip guide wire was then taken into the proximal tibia across the fracture into the distal tibia.

Before reaming was begun, care was taken to assure the reduction of the shaft component was maintained thorough the open traumatic wound with a pointed reduction clamp (Figure 7). The tibia was reamed to 1.5mm (11.5mm diameter) above the size of the anticipated nail. A 10mm nail of appropriate length was placed while the external fixator was still in place (Figure 8).

Our standard technique is to bury blunt guide wire tip into the subchondral bone above the tibial plafond, measure the length and down size by 1-2cm for appropriate nail placement. With fluoroscopy appropriate placement of the ball tip guide wire was conformed centered on both the AP and lateral radiographs of the tibial plafond. The nail was then secured with two interlocking screws proximally through the jig and two interlocking screws distally through the perfect circle technique. The external fixator

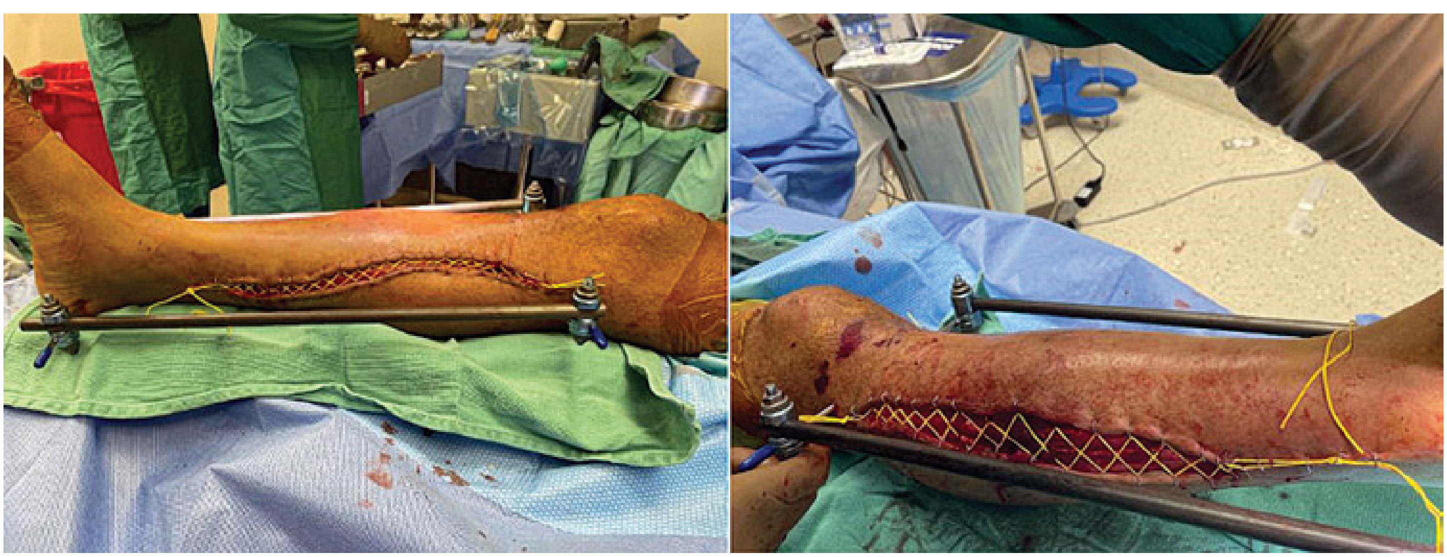

Figure 6. Intraoperative photograph demonstrating the lower extremity immediately after placement of tibial traction. The skin incisions over the sites of fasciotomies were closed with staples and vessel loops using the Roman sandal technique to allow for swelling of the compartments.

Figure 7. Intraoperative fluoroscopic imaging demonstrates application of point of reduction clamp at the fracture site with guide wire in place but prior to reaming during definitive fixation with an intramedullary nail.

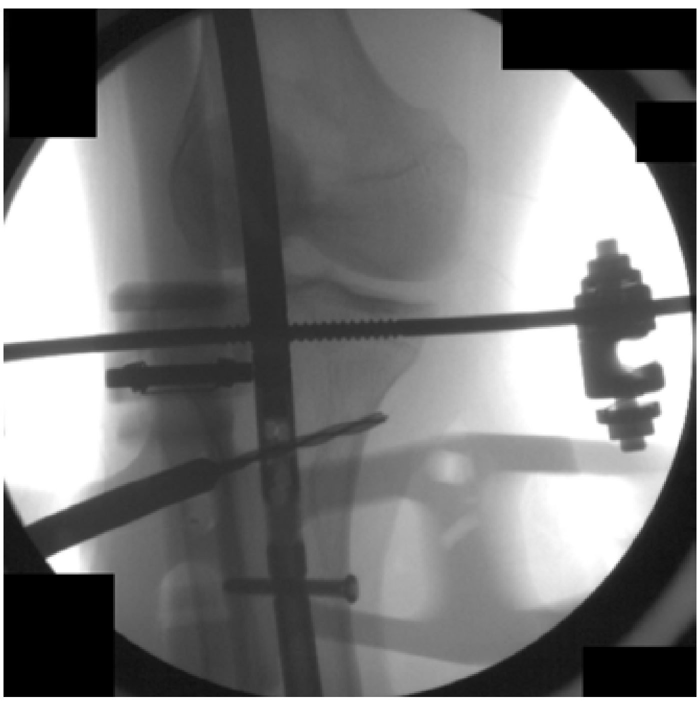

Figure 8. Intraoperative fluoroscopic imaging demonstrating tibia intramedullary nail insertion while the external fixator is still in place.

was removed once the tibia IMN was locked proximally and distally. The wound was then irrigated thoroughly, hemostasis achieved, vancomycin powder was placed in the medial and lateral fasciotomy wounds to reduce the risk of infection with this open fracture.[6] The wounds were then closed in a complex fashion with multiple retention sutures using #3-0 nylon. The rest of the surgical incisions were closed in a layered fashion with #1 Vicryl, #2-0 Vicryl, and #3-0 nylon. An incisional vac and sterile dressing were placed. Postoperative imaging of the final construct was obtained (Figure 9).

The patient was eventually extubated and an exam was able to be performed two days after tibia nail placement. He was found to have a right lower extremity foot drop at that time. The patient was eventually discharged home. At two months postop, the skin incisions were healed (Figure 10). At that time, he was ambulating with a walker

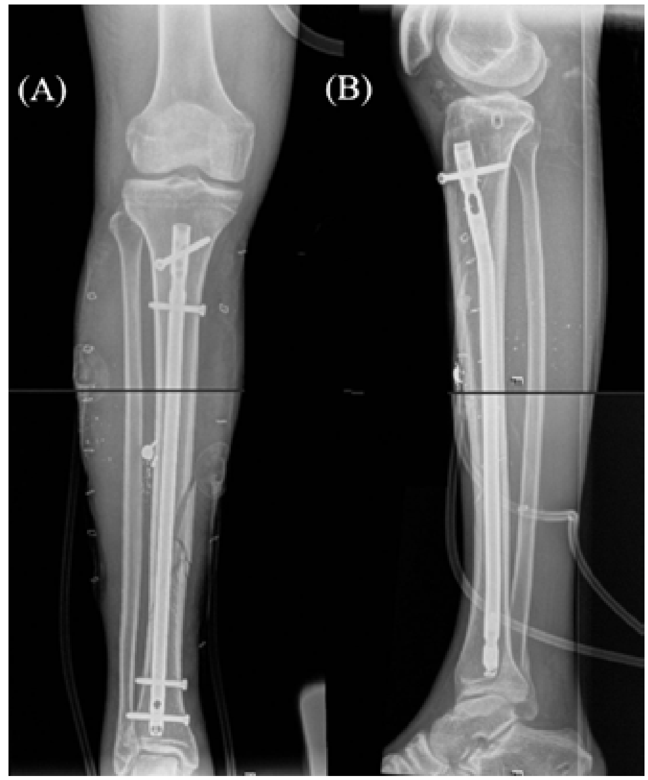

Figure 9. Immediate postoperative **(A)** AP and **(B)** lateral radiographs of the tibia IMN showing adequate length, alignment, and rotation at the fracture site. Traveling tibia traction has been removed.

Figure 10. Clinical photograph of **(A)** medial and **(B)** lateral right leg six-weeks postop. Skin incisions almost fully healed.

with a persistent foot drop. Interval callous formation was noted at the fracture site with stable hardware (Figure 11). He was prescribed a molded ankle foot orthosis (MAFO) for his foot drop and prescribed physical therapy. At two months post op, his skin incisions were fully healed (Figure 12).

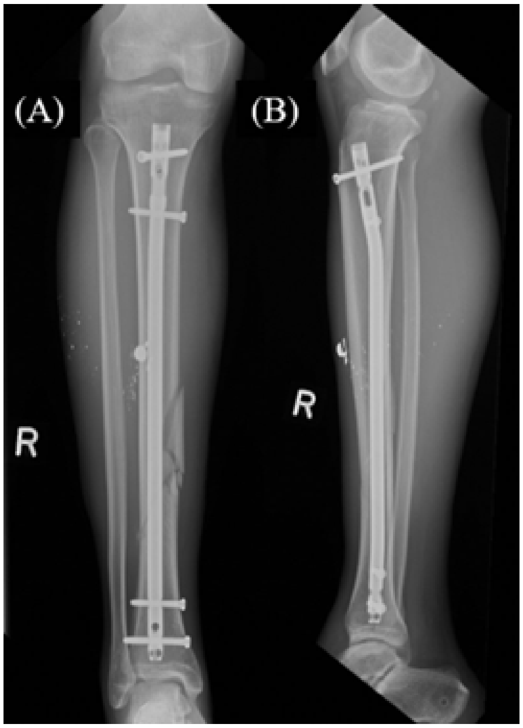

Figure 11. Six-week postoperative **(A)** AP and **(B)** lateral radiographs that show the tibia IMN in good position and interval callus formation at the fracture site.

Figure 12. Clinical photograph of the right lower extremity two months postop. Incisions well healed.

Discussion

Tibia shaft fractures are often treated surgically utilizing an intramedullary nail. However, patients who are not clinically stable enough for IMN placement require DCO and may require temporization via external fixation. In delaying the physiologic stress that may arise from IMN placement, the surgeon significantly decreases the risk of the patient experiencing a two-hit phenomenon. As such, the risk of iatrogenic morbidity and mortality decreases.[2] Additionally, in this case where a patient is undergoing surgery for emergent care to save life or limb, the senior author prefers to utilize the least invasive surgery necessary to manage the patient's injury.

Traveling traction utilizes principles of external fixation while facilitating attainment of length, alignment, and rotation for planned definitive fixation. Some authors have found that fractures reduced with a combination of traveling traction and percutaneous clamps had significantly better postoperative coronal alignment than manual reduction alone and percutaneous clamping alone.[7] This supports the use of traveling traction as a reduction tool for tibia IMN especially in challenging fractures of the proximal and distal tibia. It is also important to consider the time between initial temporization with external fixation and definitive fixation with IMN due to the risk of infection. Melvin et al. advocate for conversion from external to internal fixation as soon as the patient can tolerate and adequate soft tissue coverage can be attained to reduce the risk of infection.[8]

The orthopaedic surgery team was engaged via an intraoperative consultation. Although it would have been ideal to obtain informed consent from the patient himself or next-of-kin, neither were feasible at the time. The patient's other traumatic injuries were being managed surgically, thus he could not give informed consent for the surgical management of his tibia fracture. Moreover, his identity was unknown, so contacting a family member could not be done in a timely manner. The high risk of serious disability without emergent treatment of the fracture made this an appropriate case for the orthopaedic surgery team to operate under implied consent.[9] Despite the unplanned nature of the encounter, the physician is ethically obligated to weigh the benefits and burdens of their planned intervention and act in a way that does not cause harm to the patient.[10] Compared to options such as a delta frame external fixator or an IMN, the traveling traction technique allowed for the most minimally invasive intervention to preserve his injured limb and prevent serious disability.

Conclusion

Traveling traction is a viable option for external fixation of the tibia in clinically unstable trauma patients requiring temporary fixation. It is also a valuable reduction tool for preliminary reduction with other adjuncts like point of reduction clamps while the tibial IMN is inserted. By utilizing this technique, the surgeon can temporize the fractured limb in an unstable patient and may also obtain excellent reduction of the tibia fracture during definitive fixation without the need for additional equipment or personnel.

References

1. Melvin SJ, Dombroski DG, Torbert JT, *et al.* Open Tibial Shaft Fractures: I. Evaluation and Initial Wound Management. *American Academy of Orthopaedic Surgeon* 2010. 18(1): 10-19.

2. D'Alleyrand JC, O'Toole RV. The evolution of damage control orthopedics: current evidence and practical applications of early appropriate care. *Orthop Clin North Am* 2013; 44(4): 499-507.

3. Wysocki RW, Kapotas JS, Virkus WW. Intramedullary Nailing of Proximal and Distal One-Third Tibial Shaft Fractures with Intraoperative Two-Pin External Fixation. *The Journal of Trauma: Injury, Infection, and Critical Care* 2009. 66(4): 1135-1139.

4. Moed BR, Watson JT. Intramedullary nailing of the tibia without a fracture table: the transfixion pin distractor technique. *J Orthop Trauma* 1994. 8(3):195-202.

5. Casey D, McConnell T, Parekh S, Tornetta P 3rd. Percutaneous pin placement in the medial calcaneus: is anywhere safe?. *J Orthop Trauma* 2002. 16(1):26-29.

6. O'Toole RV, Joshi M, Carlini AR, *et al.* Effect of Intrawound Vancomycin Powder in Operatively Treated High-risk Tibia Fractures: A Randomized Clinical Trial. *JAMA Surg* 2021. 156(5):e207259.

7. Behlmer RJ, Whiting PS, Kliethermes SA, *et al.* Reduction techniques for intramedullary nailing of tibial shaft fractures: a comparative study. *OTA Int* 2021. 4(1): 095.

8. 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.

9. Cocanour CS. Informed consent- It's more than a signature on a piece of paper. *Am J Surg* 2017. 214(6): 993-997.

10. Kumar S, Tatarian T, Palazzo F. A surgeon's framework for the unplanned intraoperative consultation. *Langenbecks Arch Surg* 2023. 408(42).