JOINT TRAUMA SYSTEM CLINICAL PRACTICE GUIDELINE

Orthopaedic Trauma: Extremity Fractures

This guide describes the initial non-surgical and surgical management of extremity fractures and defines care guidelines for fractures of upper and lower extremities.

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SUMMARY OF CHANGES

1. Updated background and references.
2. Updated antibiotic guidance.
3. Added practical step-by-step guidance from Combat Orthopaedic Trauma Surgery (COTS+) Manual
4. Updated external fixator instructions to include current equipment (Stryker Hofmann III)

ORTHOPEDIC TRAUMA: EXTREMITY FRACTURES

BACKGROUND

- WWI femur FX mortality 87% → 8% with splinting
- Fracture stabilization
  - Limits ongoing hemorrhage
  - Minimizes ongoing soft tissue damage
  - Decreases pain/inflammatory response
  - Decreases ARDS/ICU + hospital days

MANAGEMENT PRINCIPLES

Early and Thorough Wound Debridement

- Open wounds → antibiotics + tetanus tox ASAP
- Early irrigation/removal of gross contamination
  - 3L per Open Fracture Grade (3L, 6L, 9L)
  - Blast → contaminants along fascial planes
- Remove debris/devitalized tissue/loose bone without periosteum or soft tissue attachments
  - Retain major joint fragments regardless
  - Paprika sign = viable cortical bone
- Preserve viable tissue
  - Muscle viability: color, consistency, contractility, capacity to bleed
- Tag, cover, preserve tendons
- Leave neurovascular structures intact
- Penetrated joint capsule → arthrotomy/irrigation
- Do NOT close traumatic open wounds
- No wound vacs near neurovascular structures
- Reassess /repeat debridement in 24-48 hours
- Date/time of last debridement always known

Fracture stabilization

- Stabilize all long bone fractures prior to movement
  - Must be suitable for transport method
  - Not constrictive or circumferential
  - Immobilize joint above and below FX
  - Restore overall length/alignment
  - Pad all pressure points
- Document neurovascular exam pre/post
- Evaluate for acute compartment syndrome
- Forearm/elbow: long-arm posterior/sugar-tong
- Humerus/shoulder: sling/swathe or coaptation splint
- Tibia: long leg splints
- Ankle/foot: below knee splints
- Ensure splint padding allows access for limb compartment

OPEN FRACTURE CLASSIFICATION

1. **<1cm; low energy; minimal soft tissue injury**
2. **1-10cm; high energy; moderate-severe tissue** damage/bone loss/displacement; high contamination
3. **>10cm; crushed tissue/contamination**
   - Adequate soft tissue coverage OR any size wound with segmental FX
   - Inadequate soft tissue coverage
   - Open FX with major vascular injury required repair for limb salvage (any size wound)

EXTERNAL FIXATION: APPENDIX A EX-FIX GUIDE

Basic Principles: Knowledge of neurovascular anatomy required

- Caution: if no basic x-ray ID of fracture pattern
  - Splint and move to facility w/ x-ray
- Ex-fix any FX requiring vascular shunt/repair
- 1cm incision/dissect to bone/no tented skin
- "Near and Far" pins (from FX) in each fragment
- Near pin 2-3cm from FX end/stay clear of joints
- Far pin as far from FX as deemed safe
- Engage pins across into far cortex for stability
  - Potential n/v structures on opposite side
- Span joint if FX near joint/involves articular bone

Lower Extremity

- Femur—anterolateral approach pin placement
  - Popliteal artery posterior distal 1/3
  - >7.5 cm from superior patella (joint)
- Knee—correct coronal/sagittal alignment
  - Knee in flexion/ control plantar flexion
- Tibia—anteromedial surface for pin placement
- Ankle—calcaneal pin medial → lateral (neurovascular bundle)

Upper Extremity

- Splint may be preferable (neurovascular structures)
- Humerus: ex-fix for vascular injury/severe ST loss
  - Lateral/anterior surfaces for pin placement
  - Radial/axillary nerve anatomy
- Ulna: palpable surface for 4mm pin placement
- Radius: 4mm pins to middle/distal 1/3 of bone
  - Expose/retract superficial branch of the radial nerve
- Elbow-spanning ex-fix: high grade open injuries
  - Unstable FX/dislocation of elbow

METRICS

- ✓ Neurovascular exam documented at every role of care
- ✓ All long bone fractures stabilized by splinting or ex-fix prior to movement
- ✓ Ex-fix used to stabilize any fracture accompanied by vascular shunt or repair

This information is pulled from the evidence-based Joint Trauma System (JTS) Orthopedic Trauma: Extremity Fractures Clinical Practice Guideline (CPG). JTS CPGs can be found at the JTS CPG website or the JTS Deployed Medicine site.

GOALS

The purpose of this Clinical Practice Guideline (CPG) is to describe the initial non-surgical and surgical management of extremity fractures; to demonstrate appropriate application of an external fixator to stabilize for transport in the setting of limited resources; and to define care guidelines for fractures of upper and lower extremities in the context of the host nation's environment and the options available to different patient groups.

BACKGROUND

The majority of combat casualties sustain musculoskeletal injuries, and the treatment of fractures and associated soft tissue wounds comprise the majority of Role 2 and Role 3 orthopedic procedures.[1-6] Recent analysis of the Musculoskeletal Orthopedic Trauma Registry (MOTR) by Benavides et al. (2025) evaluating conflicts in Iraq, Afghanistan, and Syria highlights the staggering volume and complexity of these wounds.[1] Among 4,135 battle-injured patients, a total of 25,458 distinct orthopedic injuries were identified, demonstrating a highly complex wound profile averaging 6.15 unique orthopedic injuries per patient. Extremity trauma accounted for the overwhelming majority of this burden at 93.03% (23,683 injuries), with lower extremity injuries (58.79%) presenting more frequently than upper extremity injuries (34.23%). The predominant mechanism of injury (high-energy explosive blasts) resulted in a severe fracture profile; 63.97% of combat fractures were open, and 37.78% exhibited comminution.

Appropriate wound management and fracture stabilization are the mainstays of treatment and are a critical aspect of the multidisciplinary care of combat casualties. Historically, these combat injuries were devastating. Prior to the development of long bone stabilization, mortality from isolated femur fractures was 80% in World War I, which was reduced to <15% with appropriate splinting.[7] While a patient's overall physiology and associated life-threatening wounds must be considered, the effective stabilization of long bone fractures and appropriate debridement of soft tissue injury directly contribute to effective resuscitation. The cumulative physiological burden of unsecured long bone fractures, especially femur fractures, can increase morbidity and mortality in polytrauma patients. Therefore, while resources such as imaging may be limited in austere environments, early fracture stabilization remains critical for overall patient survival and outcomes.

This massive epidemiological burden translates directly into a disproportionate utilization of theater surgical resources. A 15-year retrospective analysis of the Department of Defense Trauma Registry (DoDTR) by Stern et al. identified 51,159 orthopedic surgical procedures performed between 2002 and 2016, constituting 27% of the total combat surgical workload.[4] While the vast majority of definitive procedures (85.2%) were executed at Role 3 theater hospitals, foundational data from Turner et al. emphasize that forward surgical elements (Role 2) still perform a critical volume of early stabilizing procedures close to the point of injury.[2,3] Stern et al. demonstrated that two-thirds of the entire combat orthopedic volume was concentrated on just four critical, life- and limb-saving procedures: debridement of open fractures, fasciotomies, amputations, and the application of external fixation.[4]

The prevalence of these injuries requires that surgeons caring for victims of war must be prepared to manage complex extremity fractures in the austere environment. During recent conflicts, long bone extremity fracture stabilization has occasionally taken secondary precedence to other immediate life-saving interventions, especially as surgical teams have become smaller and more dispersed. Because a significant portion of initial stabilization and damage control orthopedics is often performed by deployed general surgeons prior to definitive Role 3 orthopedic evaluation, the establishment of clear, evidence-based clinical practice guidelines is imperative. Standardizing the approach to initial debridement, fracture stabilization, and infection control across all echelons of care ensures effective resuscitation, minimizes complications, and optimizes long-term functional recovery for the warfighter.

EVALUATION AND TREATMENT

EARLY AND THOROUGH WOUND DEBRIDEMENT [8-10,12]

- Prehospital care of extremity wounds is covered in the Tactical Combat Casualty Care guidelines [11] and in the Acute Traumatic Wound Management in Prolonged Field Care CPG, 24 Jul 2017. [12] Suspected fractures should be splinted once life-threatening injuries have been addressed. Open wounds should be treated as soon as possible with antibiotics; either oral or IV antibiotics are acceptable depending on the situation and the patient's ability to swallow medication. Traction splints may be utilized for femur fractures; however, other splinting methods may be more expedient and equally effective. A pelvic binder is indicated in cases of severe lower extremity/pelvic injury and may be utilized in conjunction with a traction splint.
- Far-forward medical facilities may not have the capability to perform formal surgical debridement, but early irrigation with removal of gross contaminants may be possible at any level of care and should be performed as soon as possible after injury.
- During the initial examination, the neurologic and vascular exam of the affected extremities should be carefully documented, and the extremities evaluated for signs of compartment syndrome (CS). Accurate documentation for the next role of care is necessary to determine any evolution of CS or the presence of a neurovascular injury.
- A thorough surgical debridement and irrigation should be performed as early as possible.[12] Indications for debridement and irrigation include traumatic arthrotomy, open fractures, contaminated or high-grade soft tissue injuries, or amputation.
    - Remove debris and devitalized tissue.
    - Smaller bone fragments without any soft tissue attachments (i.e. muscle or periosteum) should be excised. Larger fragments, especially when they contain portions of articular cartilage, should be retained and not be removed until the definitive surgical procedure at a higher echelon of care.
    - All viable tissue should be preserved in order to afford receiving physicians the greatest number of reconstructive options.
    - Transected tendons should be tagged to facilitate identification of structures during reconstruction.
    - Treat open fractures with antibiotics (see below) and administer tetanus toxoid as soon as possible.[10,13-17]
        - Patients with open fractures should be brought to the operating room (OR) for formal I&D as soon as reasonably possible (<24 hours).
    - Grade 1 or 2 open fractures (Table 1), traumatic arthrotomy, or moderately contaminated wounds should be treated with 24 hours of post-operative antibiotics.
        - Oral option: Cefadroxil 1gm PO q 24h (preferred) or Cephalexin PO 500mg QID x4
        - IV option: Cefazolin 2gm IV q6-8h
        - If Penicillin allergic: Clindamycin 900mg IV q 8h
    - Grade 3 open fractures, wounds with severe contamination, and wounds that will require soft tissue flap coverage should receive 72 hours post-operative antibiotics or until 24 hours after final fixation and coverage, whichever occurs first.[18-20] There is a lack of consensus on the optimal antibiotic protocol for these injuries; however, most recommendations include additional gram-negative coverage. Aminoglycosides may be detrimental to polytrauma patients (especially in the presence of hypotension, hypovolemia, and renal dysfunction), and therefore additional aminoglycoside use for extended gram-negative coverage is not currently encouraged.[21,22] Therefore, some proposed antibiotic protocols (depending on resources available and degree of wound contamination) for these injuries which require extended gram-negative coverage include the following:

- Ceftriaxone 2g IV daily x 72 hours (or 24 hours after coverage, whichever comes first) [23,24]
- If Penicillin allergic: Clindamycin 900mg IV q8h

- Open fractures with unique contamination must be considered for specific targeted antibiotics. While gram-positive coverage is still necessary, the following additional antibiotic coverage should be employed for the first 24 hours after surgery:
  - Freshwater open fractures: ceftriaxone or fluoroquinolone
  - Saltwater open fractures: doxycycline
  - Fecal contamination: high dose penicillin or metronidazole
- If available, addition of topical antibiotics such as vancomycin powder is encouraged for use within the deep wound space at the conclusion of I&D procedures. There is growing evidence for efficacy in preventing subsequent infection with little risk for systemic absorption or nephrotoxicity.[15,25-29]

Table 1. Gustilo Classification of Open Fractures

I	Low-energy clean wound <1 cm with minimal soft tissue injury and comminution
II	Wound >1 cm with moderate soft tissue damage and comminution. Soft tissue component <10 cm without periosteal stripping. High-energy wound with skin wound <10 cm involving extensive software tissue destruction, segmental fracture with displacement or bone loss, high degree of contamination, and vascular injury.
IIIa	Fracture wound >10 cm with crushed tissue and contamination but with adequate soft tissue coverage, or any size open wound associated with a segmental fracture (2 or more major fracture lines with intercalary fragment or fragments).
IIIb	Fracture wound >10 cm with crushed tissue and contamination, with inadequate soft tissue coverage, associated with periosteal stripping, and often requiring rotational or vascularized tissue transfer for wound coverage.
IIIc	Open fracture associated with a major vascular injury that requires repair for limb salvage.

TECHNICAL POINTS

Wound debridement should be performed as early as possible and should include extension of wound edges when required. This should be performed along the longitudinal axis of the limb, NOT transversely around the limb. Methodical exploration and inspection of the tissues should be performed within the zone of injury. There should be thorough removal of contamination and nonviable tissue spanning all levels of tissue, including skin, subcutaneous fat, fascia, muscle, and bone.

1. Indicators of muscle viability:
   - Color. Surface tissue may be discolored due to contusion, blood under the myomesium, or local vasoconstriction. This is the least reliable sign for muscle viability
   - Consistency. The ability of tissue to rebound to its initial shape after grasping with forceps. This may be the most reliable early sign.
   - Contractility. Muscle contraction is assessed by observing retraction following a pinch of forceps or by observing stimulus with an electrocautery device. If muscle is only contractile to electrocautery simulation, it may be devitalized and should be reassessed at subsequent debridements.
   - Capacity to bleed. Muscle bleeding may be difficult to detect early due to vasospasm.
   - Of note, these indicators may be unreliable during the initial evaluation.
2. Devitalized skin edges should be sharply excised.

- Skin is remarkably resilient. Excision of large areas of skin should be avoided with the exception of grossly damaged or shredded skin.
  - Utilize sharp dissection to remove devitalized tissue from wound incrementally.

3. Neurovascular structures, if in continuity, should be left intact unless a revascularization procedure is necessary for an arterial injury. If possible, neurovascular structures should be covered with muscle, fat, or skin.
4. Tendons should be similarly preserved and covered with local tissue.
5. Vacuum-assisted devices should not be used near exposed arteries, nerves, or veins. Nonadherent or emollient (i.e. Xeroform) dressings should be placed over these areas before additional dry, soft dressings are applied.
6. Repeat assessment with serial surgical debridement (every 24-48H) is beneficial and recommended for complex wounds.
   - More aggressive debridement is likely warranted if wound re-evaluation will not be possible in the subsequent 24-48 hours
7. It is challenging to appropriately balance wound debridement to minimize infectious complications with preservation of soft tissue for reconstruction as there are no objective measures or tests currently available to discern which tissue to debride versus retain.
8. Osseous Evaluation:
   - It is critical to deliver the bone ends of open fractures into the surgical field for adequate debridement of fracture edges and the intramedullary canal.
   - Open wounds that penetrate the joint capsule require an arthrotomy and irrigation of the intraarticular space. The joint capsule should be reapproximated if tissue is available for closure.
   - Bone should be evaluated for punctate bleeding (paprika sign) after soft tissue debridement, which indicates viable cortical bone.
   - Any bony fragments containing significant portions of a joint's articular surface, regardless of perceived viability, should be retained for potential delayed reconstruction and joint salvage. Smaller (<3 cm) bony fragments that lack soft tissue attachments should be removed.
9. Irrigation: After debridement, all wounds are irrigated with warm, low-pressure pulse irrigation or simple low-pressure flow through sterile tubing.
   - Volume depends on wound size and contamination.[13,30]
     Current recommendations
     - Grade 1 fractures – 3 L irrigation
     - Grade 2 fractures – 6 L irrigation
     - Grade 3 fractures – 9 L irrigation
10. Antiseptics and antibiotics are not recommended as additives to irrigation solution, as they can cause toxicity to host cells. Potable water can be utilized in austere environment if sterile solutions are unavailable.
11. If available, topical antibiotics (i.e. vancomycin powder) may be placed in the deep wound space after completion of irrigation to provide additive local antibiotic delivery.
12. Postoperative Care: Traumatic open wounds in austere environments should not be closed primarily to minimize risk of infectious complications.

13. Pearls/Pitfalls: Develop a systematic approach to all wounds to help avoid missing areas. Identify and interrogate all neurovascular injuries. Blast injuries require wide debridement as the energy can propel debris and contamination far along fascial planes.

FRACTURE STABILIZATION

1. Fracture instability, especially long bone, can compromise effective patient resuscitation due to ongoing hemorrhage, continued soft tissue damage, and respiratory splinting from increased pain. This leads to increased cytokine release, inflammatory response, and shock.[31-34] Early stabilization of femoral shaft fractures is associated with decreased pulmonary complications (including acute respiratory distress syndrome), ICU time, hospital days, mortality, and others.[35-38] Long bone stabilization is an important part of early damage control surgery by stabilizing both anatomy and physiology, and is required in the setting of a temporary shunting or definitive vascular repair. Splinting may be the only far-forward option for fracture stabilization and affords the receiving surgeon the greatest number of surgical options. Splinting also may be the most appropriate intervention for low energy fractures and those in the upper extremity and distal lower extremity such as wrist, hand, humerus, elbow, ankle, and foot fractures. An appropriate splint can be effective in temporizing any suspected or known fracture or soft tissue injury until more appropriate stabilization or imaging is available.
2. Open wounds should be addressed first, and the status of the underlying wound as well as the date and time of the most recent debridement and irrigation should be documented on the splint itself. If the patient is to be transported, splints must be suitable for the mode of transportation and acceptable within limits of passenger space. Caution should be exercised so that splints are not constrictive/circumferential, or predispose to compartment syndrome, especially prior to long evacuations. Splints should immobilize the joints above and below the fracture and provide adequate padding at pressure points to prevent soft-tissue injury. Splints are intended to limit further injury and are not meant to be definitive treatment. Anatomic reduction may not be possible or necessary for initial splinting of fractures, but a restoration of overall length and alignment of the limb should be sought. A neurovascular exam, including assessing for compartment syndrome, should be documented pre- and post-splinting with or without reduction attempts, to confirm that perfusion and function remain intact after fracture manipulation.
3. Finger and hand injuries may be immobilized with standard volar resting splints. Forearm and elbow injuries are best splinted with a long arm posterior splint or a sugar-tong splint. Humerus and shoulder fractures are best immobilized using a sling and swathe or coaptation splint, ensuring there is enough padding at the axilla. Long leg splints for tibia fractures and below-the-knee splints for ankle and foot fractures provide adequate stability for transport. Ensure the splint padding allows access for limb compartment.

EXTERNAL FIXATION

1. Due to logistical constraints and concern for infection, internal fixation is not recommended in most austere settings where evacuation to higher levels of care is possible. Surgeons should be well versed on external fixator placement for long bone and periarticular fractures.[39-40]

   In the setting of concomitant vascular injuries requiring repair or shunting, the orthopaedic surgeon and general surgeon should discuss the sequence of external fixation application (i.e. before or after the vascular procedure) considering the following:

   - Ischemia time
   - Degree of deformity in the fractured extremity, specifically the amount of shortening, angulation, malrotation, and instability across the fracture site
   - Surgeon comfort level and experience affecting speed of external fixation application

- Patient positioning required for both procedures
- Indications to proceed directly to arterial repair versus need for initial shunting

Early vascular shunting or repair offers significant benefits, including reduced ischemia time. Early fracture stabilization also plays a critical role, as it helps re-establish limb and vascular length, provides stability across the injury site, and restores tissue planes for dissection and exposure. **However, the primary priority in these cases is maintaining limb perfusion**. It cannot be overstated that orthopedic surgeons and general surgeons must work together to rapidly reestablish inflow and stabilize the bony injury. Surgical teams must remain vigilant, as vascular shunts may kink or become dislodged, and repairs may be disrupted during limb manipulation or stabilization. To mitigate these risks, the surgeon responsible for limb perfusion should remain scrubbed in, or at a minimum, be immediately available throughout the procedure to adjust the shunt or revise the repair as needed. Additionally, the team must perform frequent pulse/doppler checks during osseous fixation to ensure appropriate distal flow. This collaborative approach ensures both effective limb length stabilization and the preservation of restored blood flow.

2. External fixation provides adequate fracture stabilization to minimize additional soft-tissue trauma and can facilitate access for wound care and re-evaluation of neurovascular injury and compartment syndrome. Early fracture stabilization may blunt inflammatory mediators associated with fractures in poly-trauma[31,37] and external fixators can be rapidly applied in the polytrauma patients or in mass casualty situations. Stability afforded by external fixation is also beneficial for pain control and ease of transfers, and it minimizes the need to manipulate the injured limb during transport and at each higher level of care.

3. External fixation in the austere environment is performed under the constraints of limited equipment and the absence of fluoroscopy. Surgeons should be familiar with extremity bone and neurovascular anatomy to safely apply an external fixator for initial stabilization without fluoroscopic guidance. Otherwise, splinting should be used for temporary stabilization. Specific portable external fixation kits designed for military use include self-drilling and self-tapping pins that are advanced into the bone with hand-powered drills. External fixation has been shown to be safe in the austere environment when performed at Role 2 and Role 3 facilities.[41] However, caution is advised in attempting external fixation when no basic radiographic imaging is available to identify the fracture pattern, particularly for closed fractures where the fracture pattern cannot be visualized or palpated through an open wound. In this case, the limb should be splinted without traction, and the patient transferred to a level of care that has X-ray capability.

4. External fixator stability is improved by increasing bony apposition at the fracture site, placing the connecting bars as close to the skin as is deemed safe, increasing the distance between pins in each fracture fragment, and using the largest diameter pin possible (typically, 5.0 mm pins in long bones). Two appropriately placed pins placed into each segment (i.e. two pins above and two pins below) should provide sufficient stability and will allow receiving surgeons the most options for definitive fixation. When choosing pin sites, consider the skin incisions required for future internal fixation procedures.

5. The following guidelines allow the safe and effective placement of fixation pins in an austere environment without fluoroscopy, using only basic imaging of the fracture pattern available prior to pin placement.[42] Pins should be placed both proximal and distal from the fracture in major bone segments. The fracture ends in a closed fracture can be estimated by palpation/manipulation of the bone. The first pin in each main fracture fragment should be placed 2-3 cm away from the fracture end to improve stability. Pins placed too near the fracture can decrease the external fixator's ability to maintain stability if the pin only captures one bone cortex (i.e. only the near cortex) or is placed in fracture lines that are not grossly apparent. Pins should not be placed close enough to a joint that they violate the joint or its capsule. To place each pin, make a longitudinal incision approximately 1 cm in length at the planned pin site and bluntly dissect down to bone. The incision should be generous enough to accommodate the pin's full width, as trapped or tented skin contributes to skin irritation and pin-tract infection, ultimately leading to pin loosening. Load the pin in either a powered drill or manual driver and place the pin into the incision until the pin meets bone. The pin tip can be used to palpate the edges or curve of the bone so that the central portion may be identified. After broaching the near cortex, hand advancement of the pin should be used to allow the surgeon to feel the far cortex, which is identified by encountering increased resistance while turning the pin. Engaging pin threads across the far cortex provides

ideal stability. If intraoperative imaging is available, pins should be advanced until the pin tip is fully past the far cortex. If fluoroscopy is not available, manual advancement of 6-8 full turns after reaching the inner surface of the far cortex should provide sufficient pin engagement. Surgeons must always be aware of limb anatomy as excessive pin advancement can put neurovascular structures at risk.

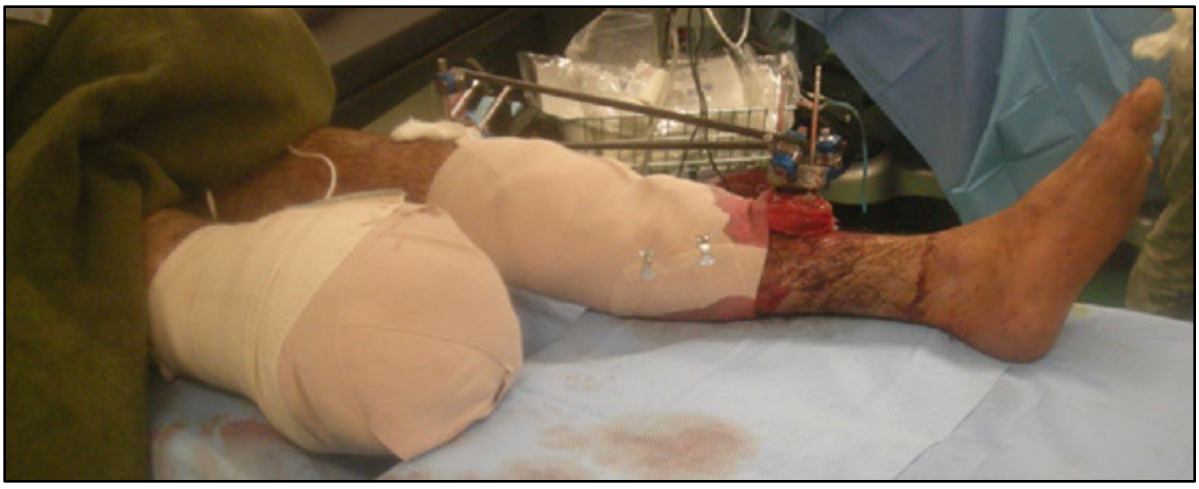
6. Intercalary fragments of segmental long bone fractures typically do not require pin fixation, and single pin fixation in these smaller fragments likely does not add to construct stability.

7. Clamps designed to connect the pins and bars are included in the equipment sets, and the pin clamp may be used as a drill guide to ensure the appropriate placement of incisions between adjacent pin sites. However, using these clamps limits the potential distance between pins in a fracture segment, and off-axis pins may not engage in the clamp sufficiently to the detriment of construct stability. External fixators may be placed to span joints if the fracture is near a joint or extends into the articular surface (knee, elbow). (Figure 1, Figure 5, Figure 7)

8. After placing the pins, the pins in each fragment can be secured together with a 5-hole pin clamp and tightened. The pin clamps (i.e. “outriggers”) have extension bars (i.e. “bull horns”) that can be connected to the long carbon fiber rods via “bar-to-bar” connectors to span the fracture. Two carbon fiber rods spanning each fracture is preferred over one rod for maximal/multiplanar fracture stability. If the available carbon fiber rods are too short to span the fracture site, 2 carbon fiber rods can be connected with a “bar-to-bar” clamp to achieve the necessary length. The overall goal of any construct is to restore length and overall alignment of the limb by establishing a provisional reduction of the fracture (thus improving stability), reduce intracompartmental volume to allow tamponade of bleeding, and to restore vascular flow by “unkinking” vessels. Without fluoroscopy, simple longitudinal traction while grossly restoring coronal and sagittal alignment is sufficient for initial stabilization. When spanning the knee, the fixator should be tightened with slight knee flexion. (See Figure 1.) At the conclusion of the case, all components of the external fixator construct should be verified to be fully tightened to prevent construct loosening (and thus loss of fracture reduction) during transfers to higher echelons of care.

9. Pins can be dressed in Xeroform or similar material and gauze, with Kerlex wrapping of the pins to provide stability to the skin. No formal pin care is recommended, especially in this acute phase, as formal cleaning protocols have not demonstrated improvements in pain, stability, or complication rates.[43]

Figure 1. Spanning external fixation across the knee joint



TECHNICAL POINTS

Basic Principles:

- In general, utilize 5 mm half pins for the tibia, femur, calcaneus, humerus, pelvis. Smaller pins (4 mm) may be useful in the bones of the forearm or midfoot/forefoot.
- The goal is to achieve bicortical fixation of each pin.
- Aim for at least 2 pins per bone segment.
- Avoid important neurovascular structures and adjacent joints.
- Attempt to stay out of the zone of injury and 2-3 fingerbreadths from fracture.
- In an austere environment, use the ex-fix components available to you. Plan your construct to ensure you have enough components for the ex-fix you are envisioning. Realize you will be limited in what you can build with what you have access to. Know your system and its capabilities.

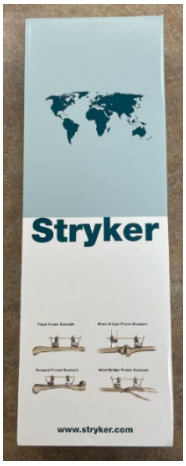
Increase stability with:

- Increased number of pins per segment
- Increased pin spread across bone segment
- Increased number of bars
- Increased pin diameter
- Increased bar diameter
- Decreased bar to bone distance
- Multi-planar construct (i.e. place pins off axis from one another)

Stryker Field Kit

This is commonly what you will deploy with if not at an established hospital facility. Be familiar with the kit and what it contains. The frames you can build are limited by the components you have access to, so be familiar with your resources. They make it extremely user-friendly with illustrations of the frames that can be built with the components in each set.

Figure 2. Field Kit A



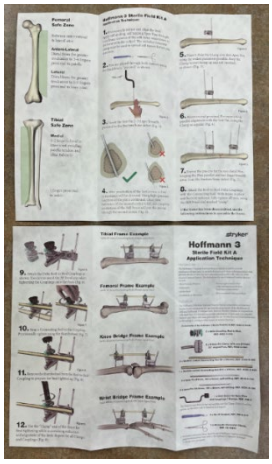
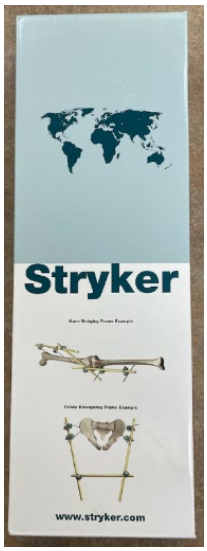
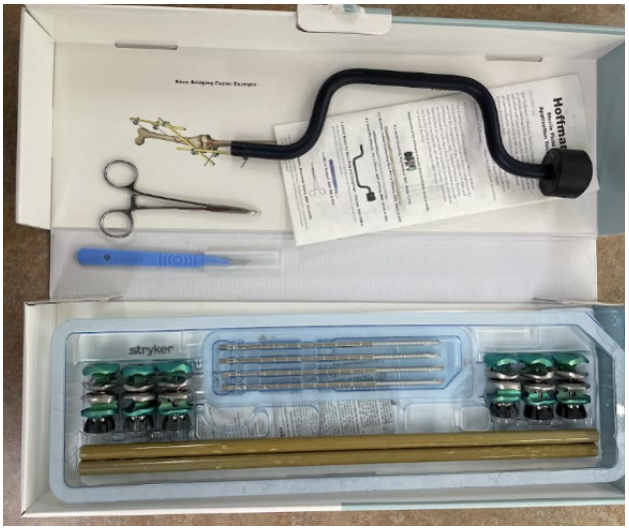


Figure 3. Field Kit B





Tips and tricks for using the hand crank

There are two sides to the hand crank, one for the pins and one for the clamps. The knob is removable, allowing you to switch from one side to the other depending on use.

If needed, make a small incision and place retractors to keep soft tissue out of the way. It is very easy and common to wrap up soft tissue around the pin when trying to advance on hand, especially in the thigh where there is considerable muscle and soft tissue.

You will likely need considerable pressure to begin advancing the pin into good-quality bone. If you have a mallet available, you may tap a few times to set the pin or use a rongeur to create a landing spot for the pin to engage.

You should feel resistance change once you engage the second cortex. Advance the pin approximately 6-8 turns past this resistance change to ensure you penetrate the second cortex.

Figure 4.Hand crank

LOWER EXTREMITY

EXTERNAL FIXATION OVERVIEW

Femur: Given the medial and posterior location of neurovascular structures in the thigh, an anterolateral or lateral approach can be used with little risk to neurovascular structures. At the distal third of the femur, however, care should be taken to avoid over-penetration of the posterior cortex, as this risks injury to the popliteal artery. Anterior pins placed in the distal femur should begin no closer than 7.5 cm above the superior pole of the patella to avoid inadvertent intraarticular placement.[44]

Figure 5a. Femur pin

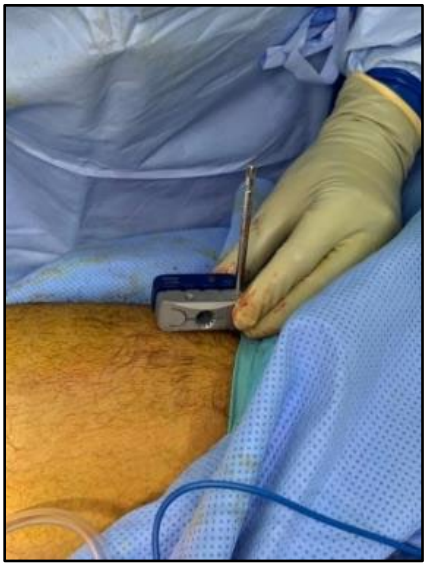
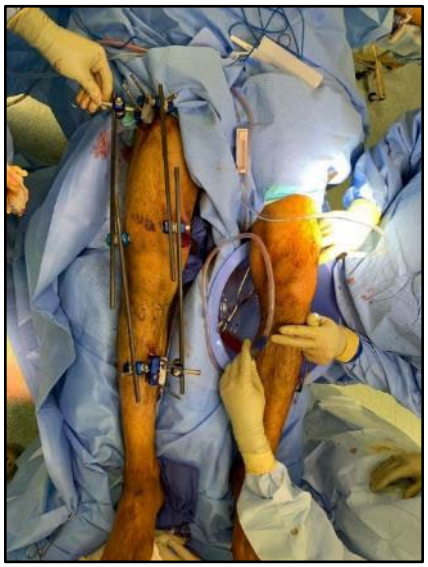


Figure 5b. Knee spanning fixator of right knee.



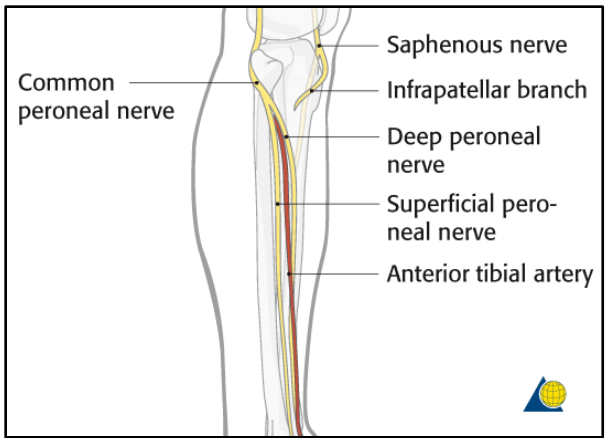
Knee: For distal femur and/or proximal tibia fractures including those involving the articular surfaces, a knee spanning fixator is most appropriate. Two pins each in the intact femur and tibia can be connected by bars. To maximize stability of this longer construct, adequate pin spread and/or multiple bars should be considered. As with other long bone fractures, longitudinal traction is used to correct coronal and sagittal alignment. The fixator should be locked with the knee in slight flexion (~30 degrees). A posterior slab short-leg splint can be helpful to control ankle plantar flexion and provide additional soft-tissue rest and pain control, as the gastrocnemius muscle crosses the knee joint.

Tibia: The neurovascular bundle runs along the bone's posterolateral surface. This leaves the anteromedial surface free for safe pin placement. The thin layer of subcutaneous tissue overlying the bone makes this surface easily palpable along its entire length. The direct anterior tibial crest should be avoided as it is significantly thicker than the rest of the bone, and pin placement is difficult even with a power drill. Pins should be placed about 1 cm medial to the anterior crest to avoid the crest, as excessive drilling can result in thermal necrosis, pin loosening, and eventual infection.

TIBIAL PIN PLACEMENT

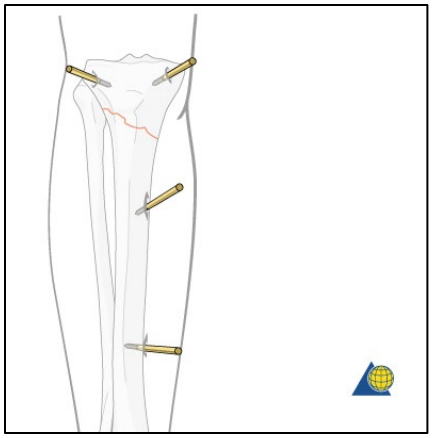
Figure 6a. External view of tibia pin placement

Figure 6b. Lateral view of tibia



Lateral view of tibia showing location of neurovascular structures to avoid during tibial pin placement. Structures are posterolateral and are easily avoided with placement of pins on anteromedial face of tibia.

Figure 6c. Anterior view of tibia with pins



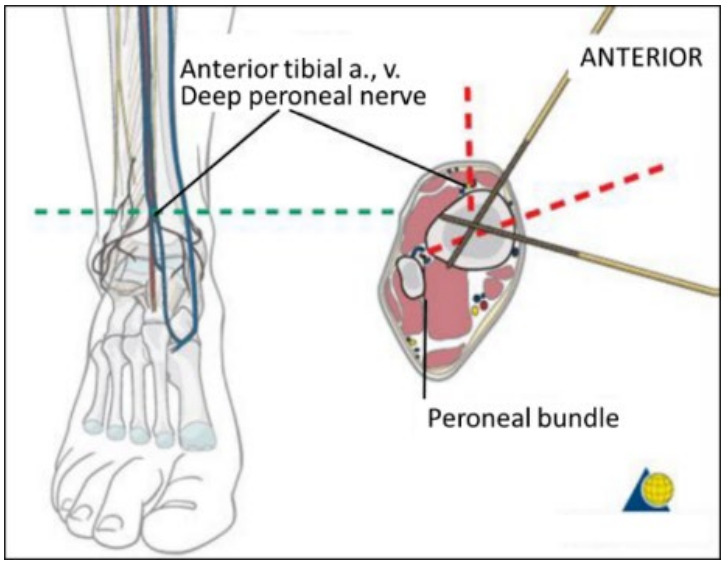
Anterior view of tibia showing potential pin placement for a proximal tibia fracture. A knee-spanning fixator is also an appropriate option in this case.

Source: Courtesy of Marcel Erismann, Senior Medical Illustrator, AO Foundation

Fibula: External fixation of the fibula is not indicated despite any amount of associated tibia or soft tissue injury.

Ankle: To stabilize the ankle (typically in the setting of an unstable distal tibia fracture), two pins should be placed in the tibia proximal to the fracture site and be connected to a centrally-threaded trans fixation pin placed through the calcaneus using a medial-to-lateral approach to avoid injury to the neurovascular bundle located just posterior to the medial malleolus (Figure 7a below). To span the ankle joint, most surgeons elect to use a single transfixation calcaneal pin placed from medial to lateral (i.e. delta frame, Figure 7b below). If needed, sufficient ankle dorsiflexion can be maintained with the addition of a posterior slab splint. Alternatively, to a posterior slab splint, a 4 mm pin can be placed in the first metatarsal to control ankle dorsiflexion; however, stable placement can be difficult, and the tibialis anterior tendon at the base of the bone can be at risk. Talar neck pins, with appropriate anatomic knowledge, can be useful to stabilize the distal tibia, particularly if a calcaneal fracture is present that precludes transcalcaneal pin placement.

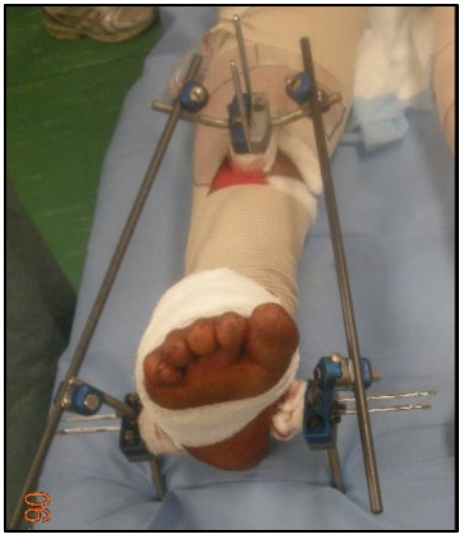
Figure 7a. Pin placement for ankle stabilization



Source: Courtesy of Marcel Erismann, Senior Medical Illustrator, AO Foundation

Figure 7b and Figure 7c. Delta frame

Example of an ankle-spanning "delta frame" with 2 trans fixation calcaneal pins necessary to connect bars to the pin clamps when no pin-to-bar connectors available. Two pins may lessen the need for a posterior splint, but a splint can be useful for additional soft tissue protection and to prevent forefoot plantarflexion. Note the addition of the two short "kickstand" bars posteriorly that decreases direct pressure on the heel.



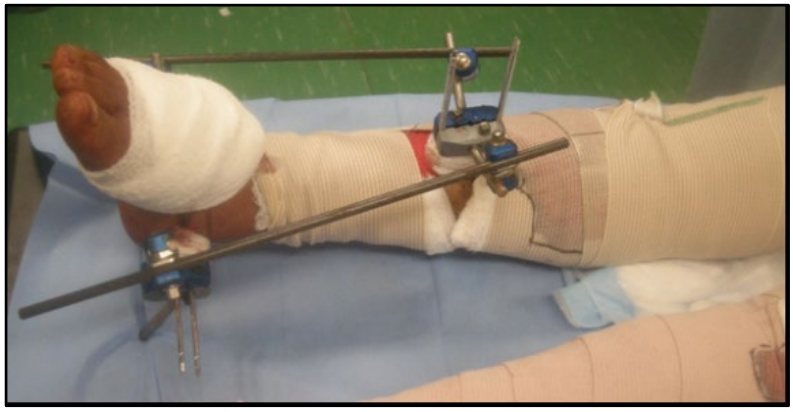


Figure 8. Use of spanning external fixation to stabilize blast injury to lower extremity

Basic radiographic imaging obtained prior to procedure demonstrated comminuted distal 1/3 femoral and mid-shaft tibial fractures. A spanning external fixator was placed across the knee joint, and an expanded "delta frame" external fixator uses the proximal tibial pin clamp site to stabilize the segmental tibial fracture.

Figure 8a. Comminuted distal femoral fracture

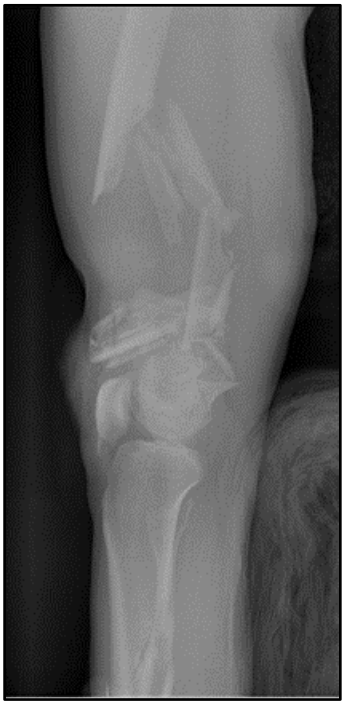


Figure 8b. Mid-shaft tibial fractures

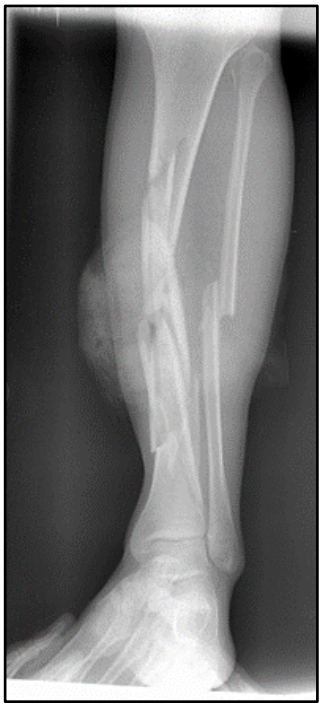


Figure 8c. External fixator

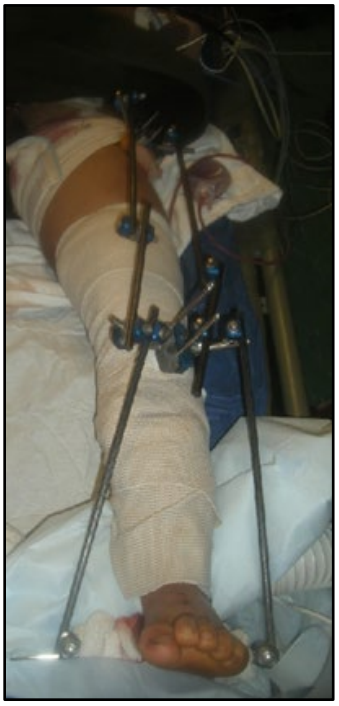
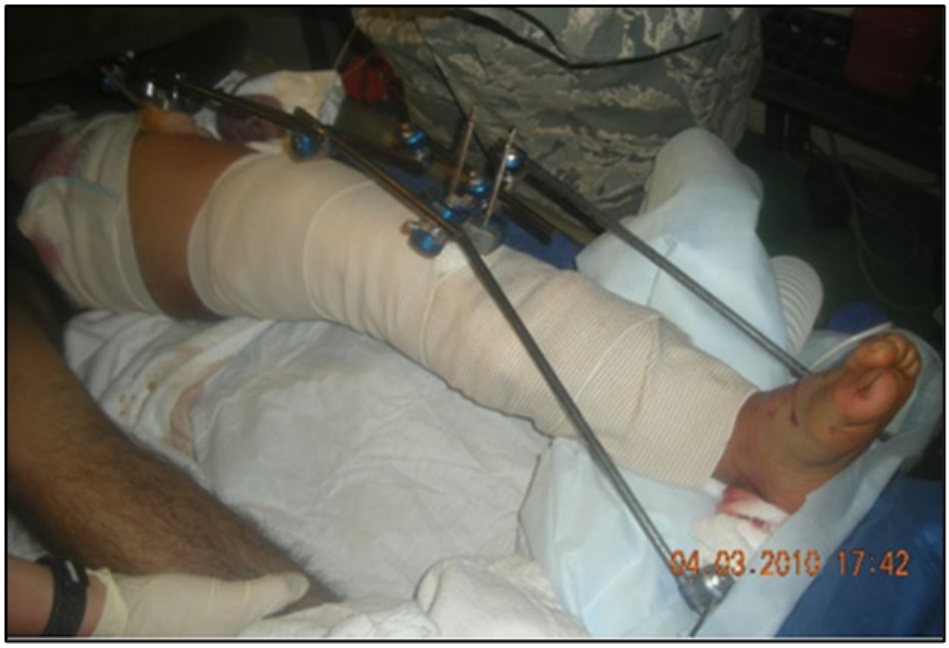


Figure 8d. Delta Frame external fixator

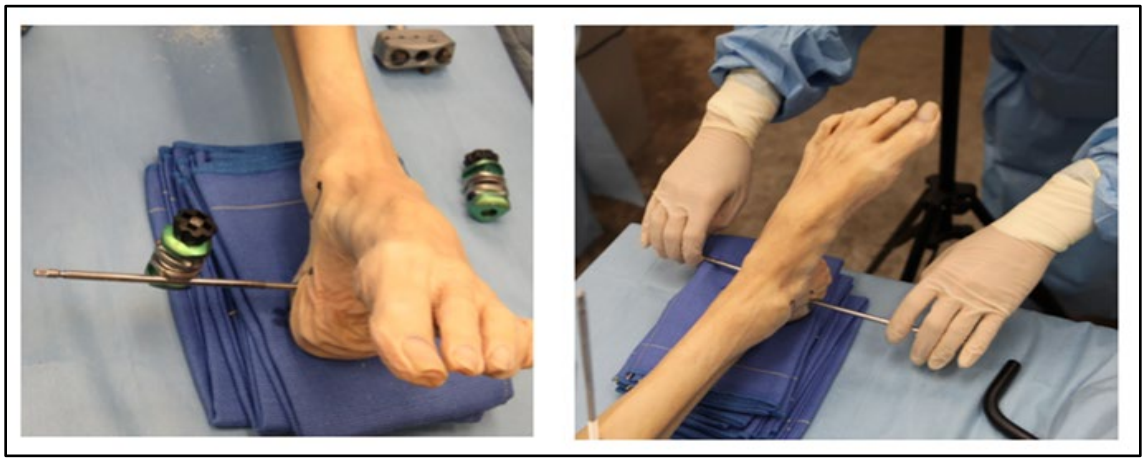


TECHNICAL POINTS ON LOWER EXTREMITY FRAME CONSTRUCTS

Ankle Spanning External Fixation (Delta frame)

1. Clinical Indications
    a. Length-unstable injury to the tibial plafond.
    b. Inability to maintain closed reduction of a fracture or fracture dislocation in a splint safe for transport.
    c. Temporizing soft tissue stability in high-grade open injuries of the distal tibia and ankle.
2. Key Anatomy
    a. Avoid the medial and lateral plantar nerves with calcaneal pin placement.
    b. The tibia is a rather subcutaneous bone with a wide safe zone anteromedially.
3. Steps
    a. Calcaneal Pin Placement
        i. Landmark for pin placement is approximately one-two fingerbreadths distal and posterior to the tip of the medial malleolus if no fluoroscopy is available to localize placement.
        ii. Place a centrally threaded pin into the calcaneus from medial to lateral.
        iii. If you do not have a centrally threaded pin, you may place a unilateral frame or utilize two half pins- one directed medial to lateral and one directed lateral to medial to simulate a centrally threaded pin.

Figure 9a and Figure 9b. Calcaneal pin placement



    b. Tibial pin placement
        i. Plan your pin placement based on the injury pattern and the planned frame construct, using what you have available.
        ii. Direct anterior to posterior pins
            1) Make a percutaneous incision over the area of desired first pin placement. (generally, 1cm medial to the prominent anterior tibial crest)
            2) Use Kelly hemostat clamp to spread directly down to bone.
            3) The tibia is a triangle, so it has a sloped anteromedial face which is easy to skive off. Start the pin perpendicular to the bone, even though this will not be the final trajectory.

4) Once the pin is engaged, slowly raise your hand so the pin is headed along the appropriate anterior-to-posterior trajectory.

5) If using an outrigger, you can place the outrigger over the first pin to help localize placement of the second pin. Use the 2 furthest slots to optimize pin spread if able.

Figure 9c. Tibial Pin Placement

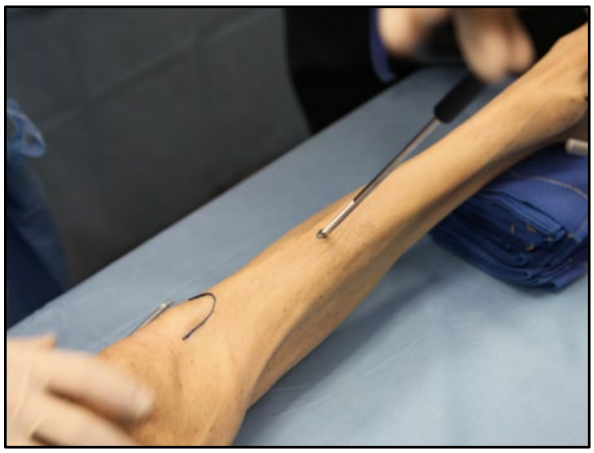


Figure 9d. Tibial Pin Placement

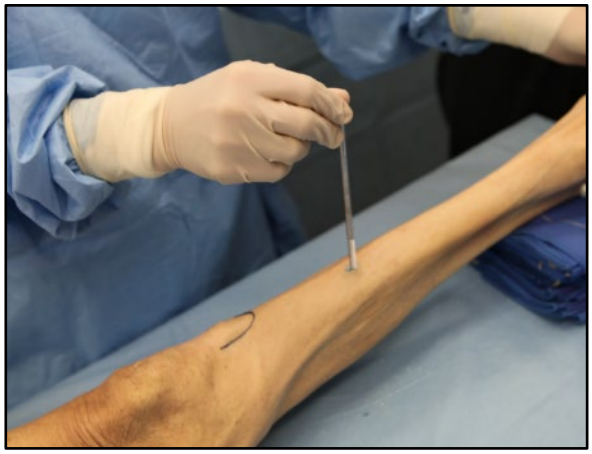
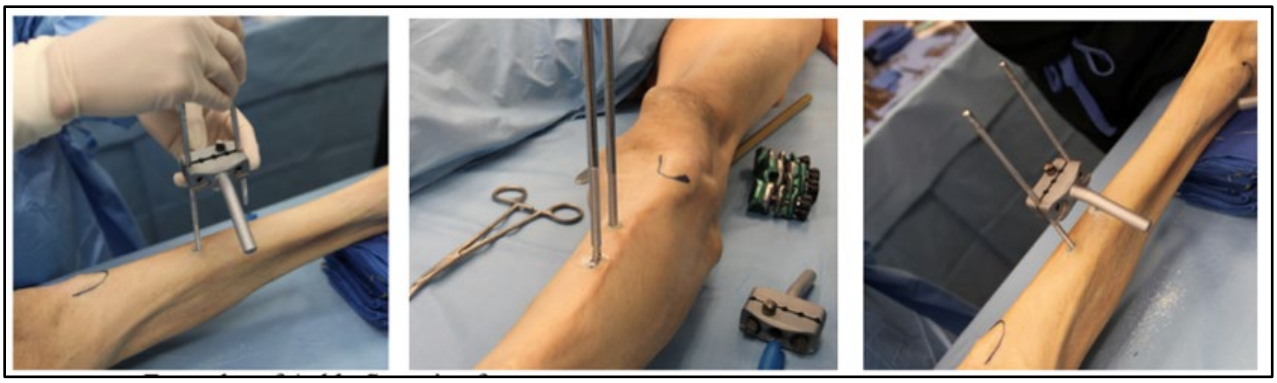


Figure 9e. Tibial Pin Placement

Figure 9f. Tibial Pin Placement

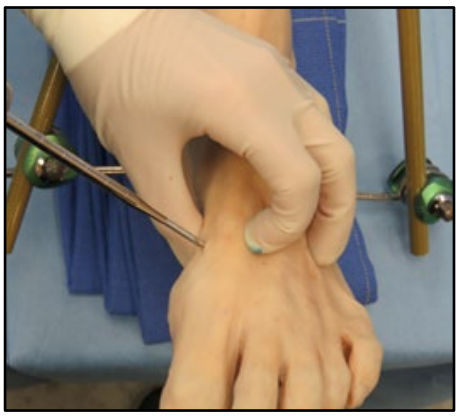
Figure 9g. Tibial Pin Placement



For increased stability, you can add a pin into the 1st metatarsal.

i. Localize the base of the 1st metatarsal by palpation of the 1st TMT joint if no fluoroscopy is available.

Figure 9h. Pin Placement in 1st Metatarsal

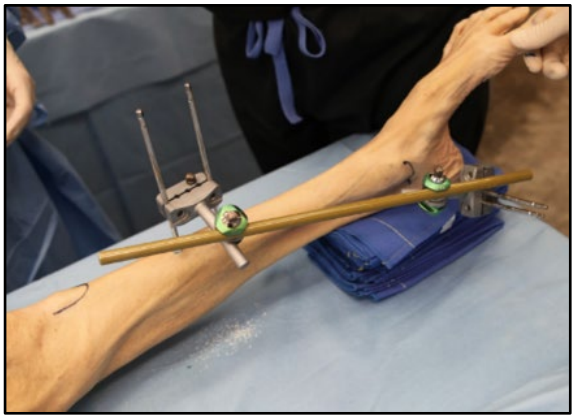


ii. Proximal shaft of first metatarsal may accept pins perpendicular to long axis of metatarsal; do not enter base of metatarsal, as this may tether the tibialis anterior tendon.

iii. Use a 4.0 mm pin if available.

EXAMPLES OF ANKLE- SPANNING FRAMES

Figure 10a and Figure10b. Unilateral frame



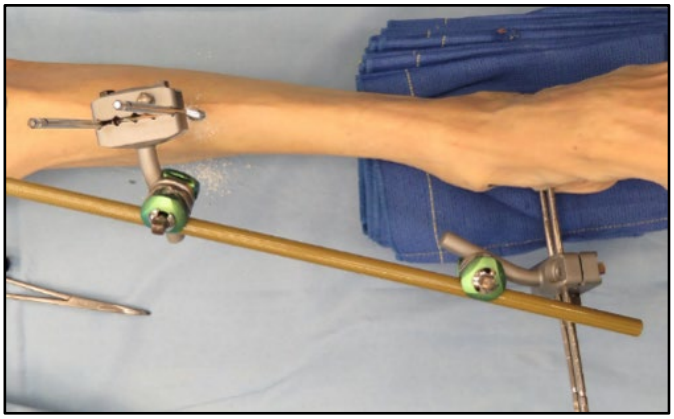
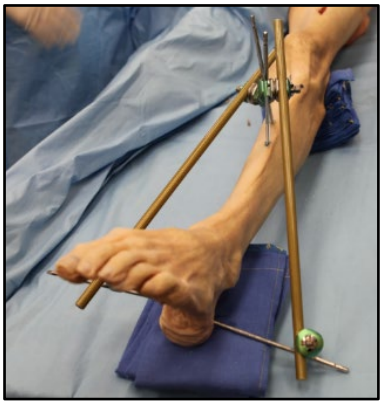


Figure 11a and Figure 11b. Centrally Threaded Calcaneal Pin Delta Frame



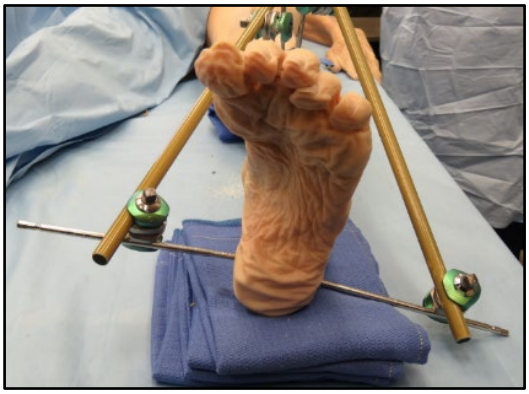
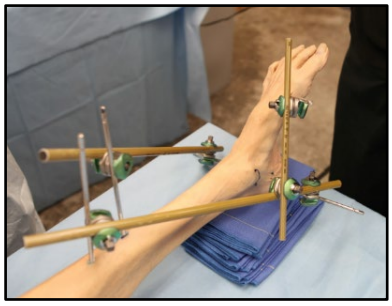
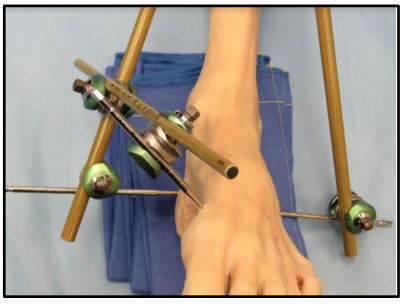
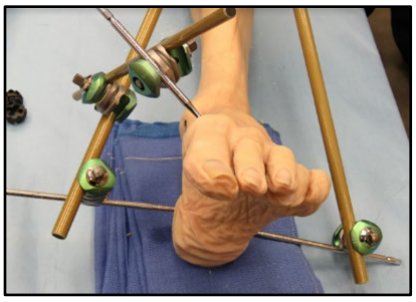


Figure 12a, Figure 12b, and Figure 12c. Frame with added 1st Metatarsal Pin





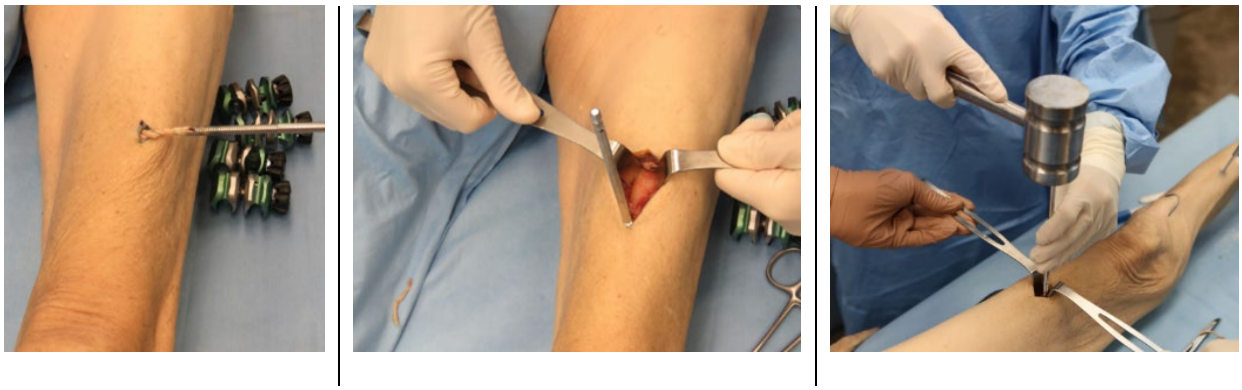


4. Pearls/Pitfalls
    a. In an austere environment, a unilateral fixator may suffice for safe transport to a higher level of care.
    b. Care must be taken not to over-penetrate the far cortex in tibia pins and cause damage to the neurovascular bundle.

Knee Spanning External Fixation

1. Clinical Indications
    a. Temporizing stabilization of distal femur fractures or length-unstable injury to the tibial plateau.
    b. Inability to maintain closed reduction of knee dislocation.
    c. Temporizing soft tissue stability in high-grade open injuries to the distal femur or proximal tibia.
    d. Temporizing immobilization of the knee joint around a high-risk vascular shunt.
2. Key Anatomy
    a. Be mindful of the femoral nerve anteriorly the more proximal you place femoral pins.
3. Steps
    a. Tibial pin placement: as described above.
        i. Attempt to stay out of zone of injury and future definitive fixation location.
    b. Femoral pin placement
        i. When placing a knee-spanning external fixator, it is often easiest to place the pins in the same plane as the tibial pins (i.e. anterior to posterior). You may also place pins anterolateral or lateral. **Be mindful that the more proximal you get, the less safe straight anterior pins will be.**
        ii. Place femoral pins at least a hand breadth above the patella to avoid placing pins into the intra-articular suprapatellar pouch.
        iii. It is very easy to entangle soft tissue when placing femoral shaft pins with one hand. If this happens, have a low threshold to make a slightly larger incision to aid in soft tissue retraction.
            1) You can make an incision just large enough to place two Army-Navy's in to help create a clear path down to bone.
            2) You can also use a mallet to impact the pin into the bone to help prevent it from skiving off the rounded surface of the anterior femur.

Figure 13a, Figure 13b, and Figure 13c. Femoral Pin Placement



c. Frame construction

i. Place a bump under the knee to create a small amount of knee flexion to relieve stretch on the neurovascular structures.

ii. Place at least two pins in the tibia and two in the femur.

iii. Connect with clamps, bars, outriggers as needed.

4. Pearls/Pitfalls

a. Femur pins too lateral and tibial pins too medial can present a problem when placing bars and clamps to assemble frame and perform reduction.

b. Don't be afraid to make an incision to aid in expedient pin placement.

KNEE SPANNING FRAME EXAMPLES

Figure 14. Single Bar Frame

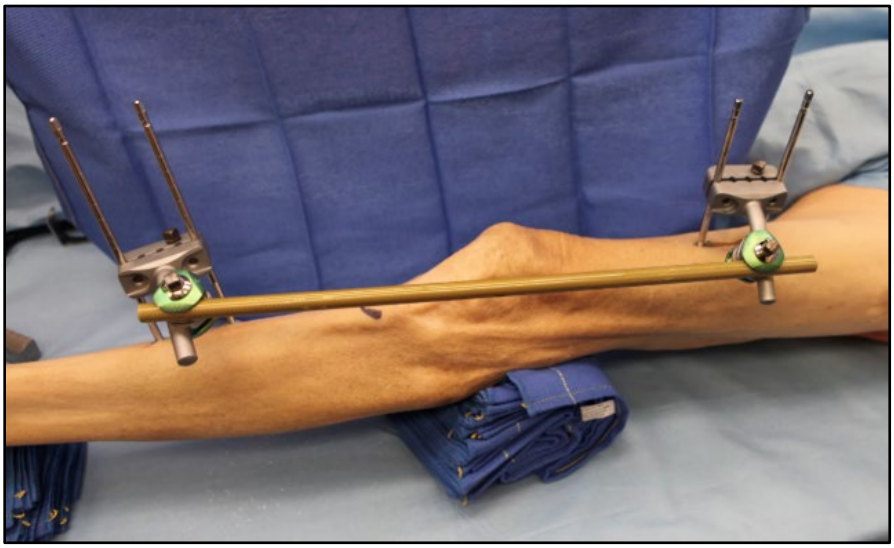


Figure 15. 2 Bar Frame

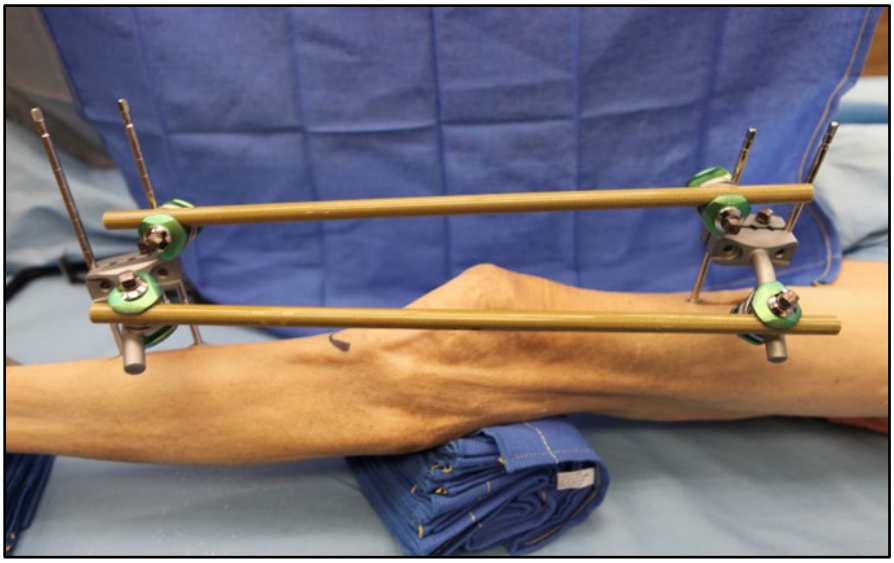
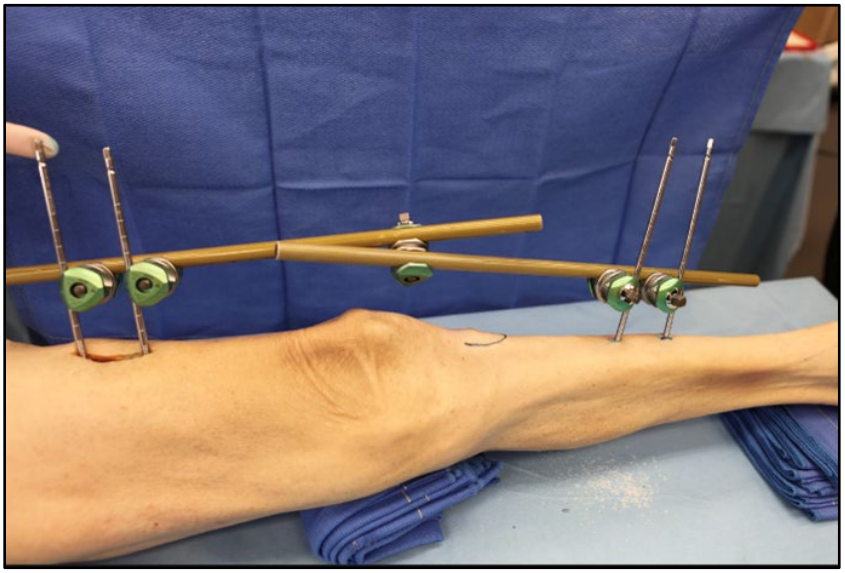


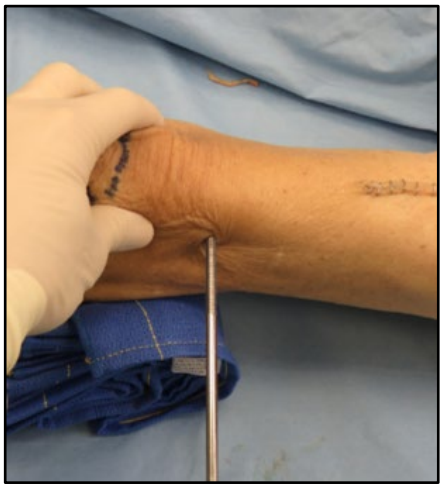
Figure 16. Variation of 2 Bar Frame

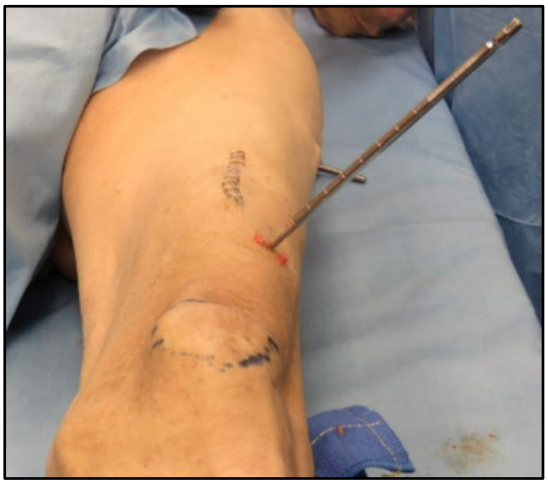


External Fixation of the Femoral Shaft

1. Clinical Indications
    a. Temporizing stabilization of femoral shaft fractures.
    b. Temporizing soft tissue stabilization in high-grade open injuries to the femoral shaft.
    c. Temporizing stabilization for femoral vascular shunt.
2. Key Anatomy
    a. Keep in mind the course of the femoral nerve proximally in the femur when considering pin placement.
3. Steps
    a. Place two femoral pins proximal to the injury and two femoral pins distal to the injury, utilizing the principles of femoral shaft pin placement above. Remember the safe zones in the femur; you may place pins anterior, anterolateral, or lateral pending preference and comfort.

Figure 17a and Figure 17b. External Fixation of the Femoral Shaft





b. To remain extra-articular, place the most distal pin one hand breadth proximal to patella.

c. It is not recommended to place pins into the femoral neck without fluoroscopy.

d. Assemble frame with clamps, bars, and outriggers as needed.

4. Pearls/Pitfalls

a. Aim for clinically aligned, stable limb and restoration of length in a true damage control orthopedics situation.

b. Do not over-penetrate the cortex medially as this may put the profunda femoris artery at risk.

c. Consider your medevac space restrictions when constructing your frame. Smaller helicopters may not be able to accommodate a bulky lateral frame.

d. If you have a comminuted proximal femur fracture, you may place pins into the iliac crest for proximal stability.

e. Make an incision if needed to avoid soft tissue interference with pin placement.

FEMORAL SHAFT EXTERNAL FIXATOR EXAMPLES

Figure 18. Lateral Frame

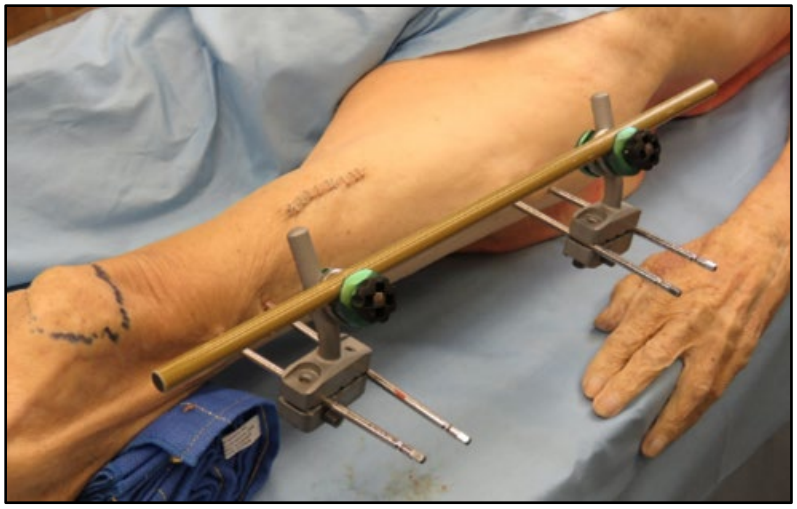


Figure 19. Double Bar Lateral Frame

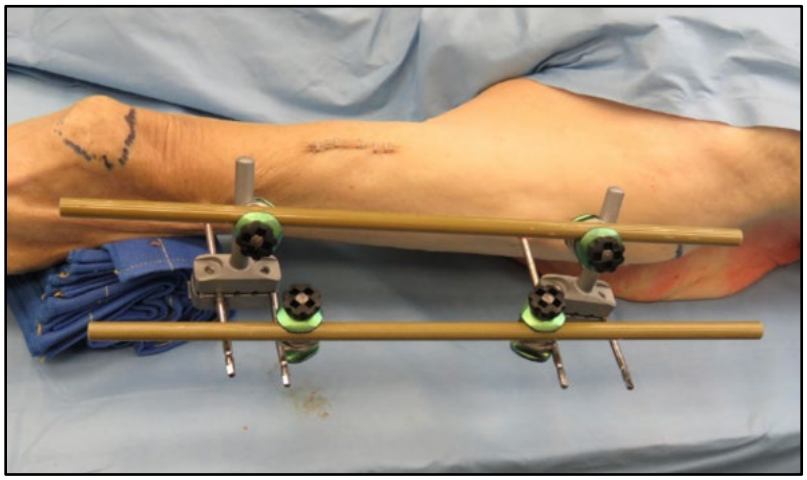


Figure 20. Anterolateral Frame

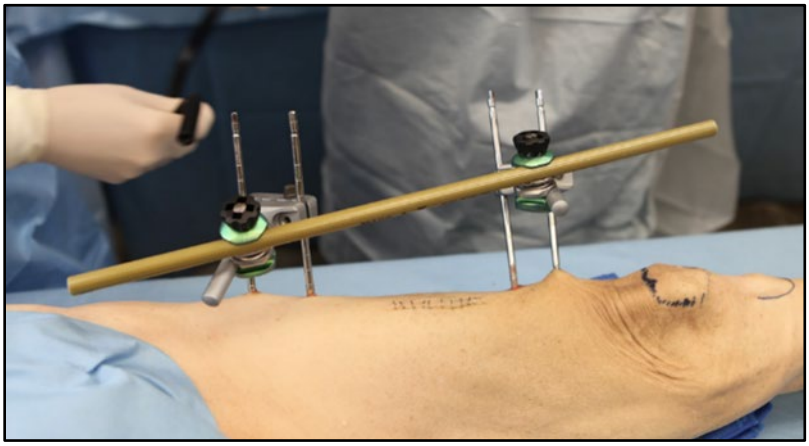
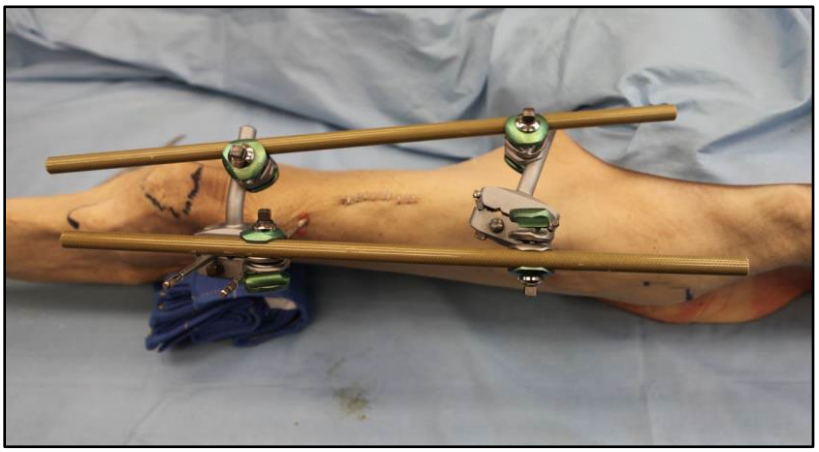


Figure 21. Double for Anterolateral Frame



UPPER EXTREMITY

EXTERNAL FIXATION OVERVIEW

Splinting of the upper extremity is often preferable over the use of an external fixator, especially for isolated injuries. Upper extremity external fixators are more difficult to place due to the proximity of neurovascular structures. Familiarity with upper extremity anatomy and careful dissection before pin placement can reduce the risk of injury.

Humerus: External fixation of the humerus can be particularly risky due to the intimate relationship with the neurovascular structures. External fixation should be reserved for instances of severe soft-tissue destruction or when associated vascular injury requires shunting or repair. In general, the lateral and anterior surfaces are safer for half-pin insertion. Over-penetration of the medial cortex places the neurovascular bundle at risk for injury. For fixation around the elbow, half pins are placed proximal to the lateral epicondyle. An incision of sufficient length is required to positively identify the radial nerve as it traverses anteriorly between the biceps and brachioradialis about 10-14 cm proximal to the lateral epicondyle. After pin placement, the incision is closed around the pins.

Ulna: The dorsal surface of the ulna is easily palpable along its entire length. The ulnar nerve is located radial and volar to the bone, making the palpable surface an ideal site for pin placement. 5mm pin diameters can be too large for the bone diameter, and 4mm pins should be used instead.

Radius: At the proximal third of the radius, the dorsal surface is obscured by the variable course of the posterior interosseous nerve. Accordingly, pin placement should be limited to the radial surface of the more palpable middle and distal third of the radius to avoid injuring the radial nerve motor branches. An incision allowing sufficient dissection to expose and retract the branches of the superficial branch of the radial nerve and underlying tendons is necessary to avoid entrapment or damage of these structures. As with the ulna, 3-4 mm diameter pins are often more appropriate due to the size of the radius at the location the pins are being placed.

PIN PLACEMENT IN THE FOREARM

Upper extremity external fixator applied for open comminuted intra-articular distal humerus fracture with associated brachial artery injury from a high velocity gunshot wound. An expeditious spanning external fixator was used with smaller pins placed in the distal radial third of the radius, followed by arterial shunting of the brachial artery, followed by debridement and irrigation of the wounds.
Note: The distal radial pin was adjusted after postoperative radiograph to correct over penetration.

Figure 22a. Distal Humerus Fracture Brachial Artery

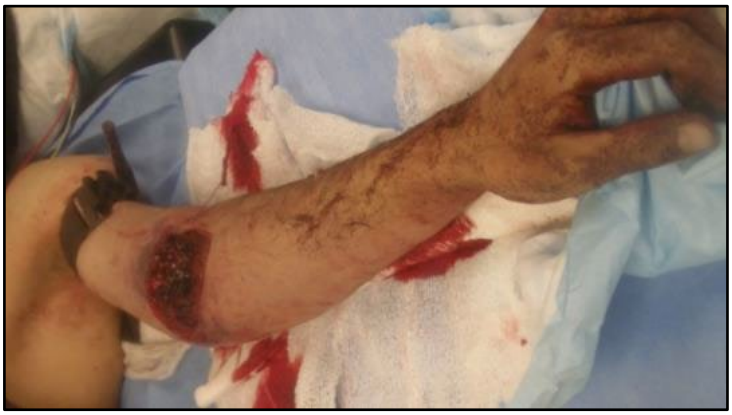
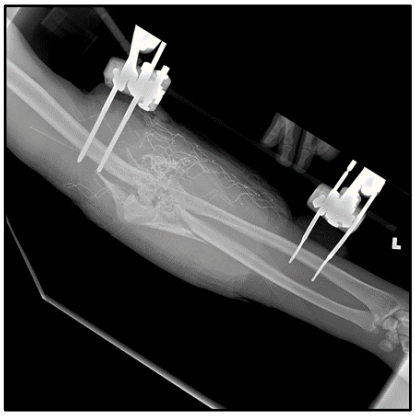


Figure 22b. X-ray of distal radial pin

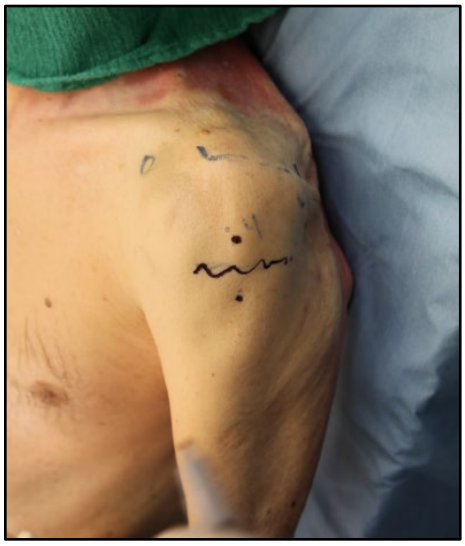


TECHNICAL POINTS ON UPPER EXTREMITY FRAME CONSTRUCTS

External Fixation of the Humerus

1. Clinical Indications
    a. Temporizing stabilization of humeral shaft fracture unable to be managed with a splint.
    b. Temporizing soft tissue stabilization in high-grade open injuries to the humeral shaft.
    c. Temporizing stabilization of humeral shaft fracture in the setting of vascular shunt.
2. Key Anatomy
    a. The axillary nerve is found between 5-7 cm distal to the lateral border of the acromion.
    b. The radial nerve crosses the posterior humeral shaft 21 cm proximal to the medial epicondyle and 14 cm proximal to the lateral epicondyle.
3. Steps
    a. You may place pins anteriorly or laterally on the humeral shaft as dictated by injury and preference.
    b. Incisions should be made to avoid potential neurovascular injury with aberrant pin placement.
    c. Proximally, mark out the course of the axillary nerve and take caution when working around this area if placing lateral pins.

Figure 23a and Figure 23b. External Fixation of the Humerus



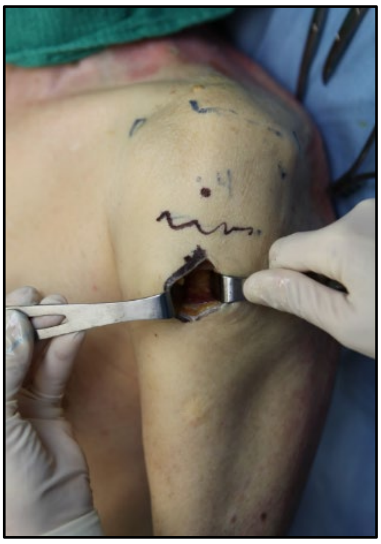
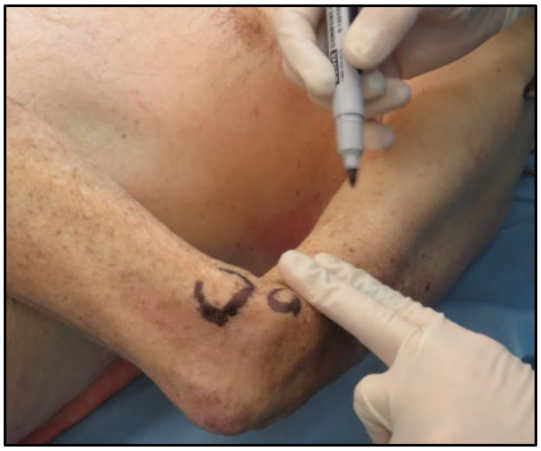
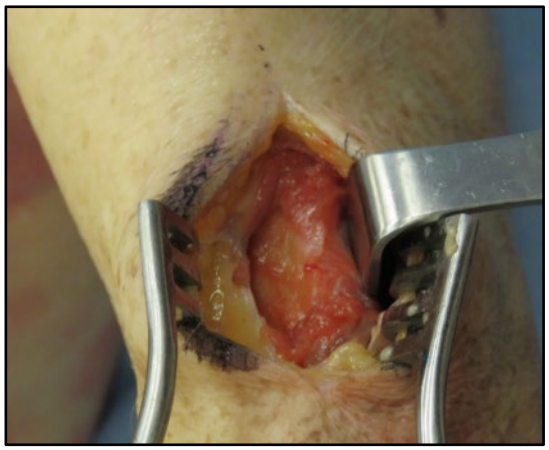


Figure 23c and Figure 23d. External Fixation of the Humerus





d. Place two pins proximal to the zone of injury through this incision.

e. Distally, mark out the lateral epicondyle and radial head. The radial nerve should course approximately two fingerbreadths proximal to the lateral epicondyle.

f. Place two pins distally through another open incision to take care to protect the radial nerve. The distal humerus can be quite narrow and sharp at this level, so take care not to skive off bone and injure the nerves.

4. Pearls/Pitfalls

a. Do not over-penetrate medial cortex proximally so as not to damage neurovascular bundle.

b. Proximally, avoid palpable deltoid tendon.

c. At mid-shaft, do not over-penetrate posterior cortex so as not to damage radial nerve.

d. The epicondyles may be transfixed distally, with caution given to ulnar nerve medially.

Figure 24. Humeral Shaft External Fixator

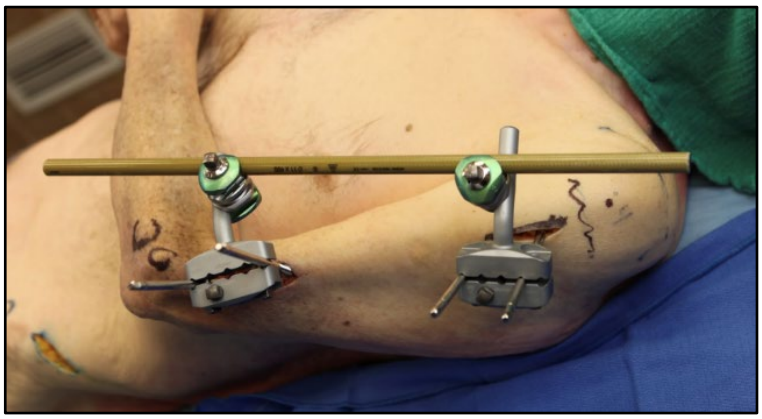
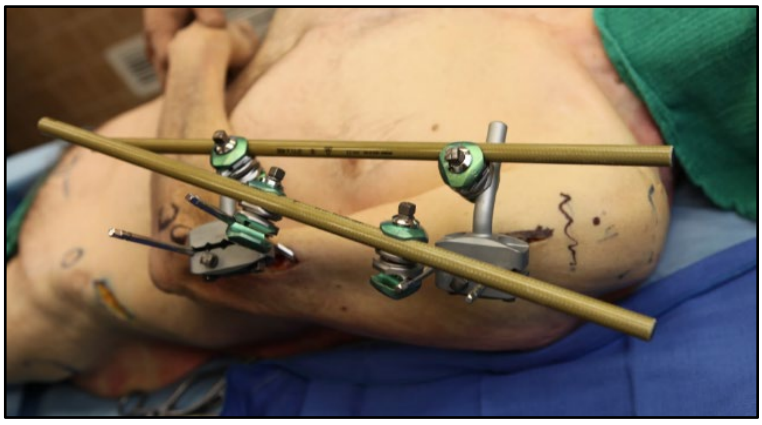


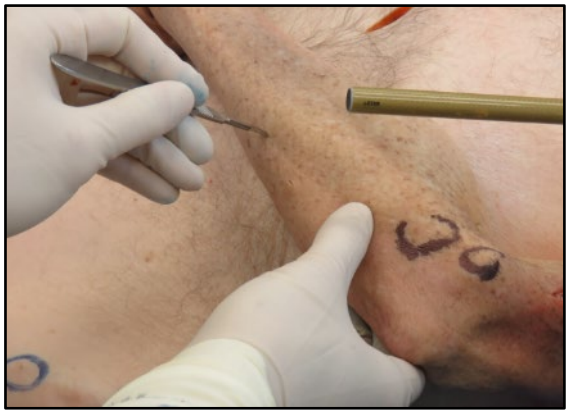
Figure 25. Double Bar Humeral Shaft External Fixator

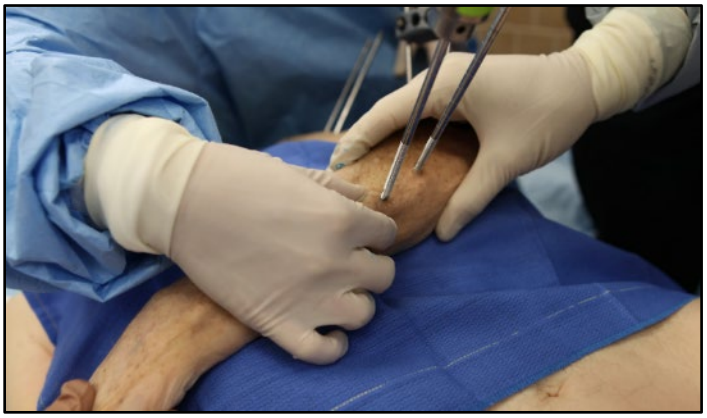


Elbow-Spanning External Fixation

1. Clinical Indications
    a. Temporizing stabilization of distal humerus or severe proximal forearm fractures unable to be managed with a splint.
    b. Temporizing stabilization of highly unstable elbow dislocation or fracture-dislocation.
    c. Temporizing stabilization of high-grade open injuries to the distal humerus or proximal forearm.
2. Key Anatomy
    a. Same as for humeral shaft pin placement; depending on pin location in upper segment.
    b. Distally, the ulna is subcutaneous, so there isn't a significant neurovascular bundle to watch for.
3. Steps
    a. Place two proximal pins into the humerus based on injury pattern and preference. Again, you may place anterior or lateral pins. Make an incision and protect the nerves.
    b. Two distal pins will be placed into the ulna. If 4 mm pins are available, those are preferable to 5 mm pins given the small size of the ulna.
    c. Make a percutaneous incision over the subcutaneous ulna and place two pins into the ulnar shaft.

Figure 26a and Figure 26b. Elbow spanning External Fixation



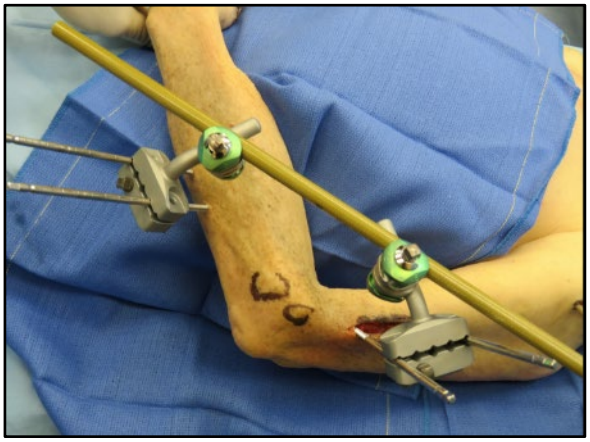


d. Construct your frame to maintain approximately 90-100 degrees of flexion of the elbow and neutral forearm rotation.

4. Pearls/Pitfalls

a. Keep the final frame orientation in mind when placing the pins so the bars connect easily.

Figure 27. Single bar elbow spanning external fixator



HOST NATION CASUALTIES

One particular challenge for medical providers in an under-resourced host nation is the likelihood of treating individuals with unknown follow-up care. Providers need to understand the trauma system in which they work to know what is best for the host national patients that present to a Role 2 or Role 3 MTF. Low-energy, closed fractures may be treated definitively with a splint or cast. Plaster often is preferred to fiberglass for casting, as cast saws may not be locally available and fiberglass can be removed by soaking the cast in water. Certain low-energy fractures may warrant open reduction and internal fixation or closed reduction and percutaneous pinning. External fixation is also an option for initial stabilization if transfer to a host-nation facility is possible, or if the tempo of casualties allows for delayed internal stabilization. External fixation can be used successfully to definitively treat fractures but requires careful pin placement, long-term construct stability, and close follow-up that may not be possible. In the setting of high-energy wounds with extensive soft tissue loss, a staged amputation that may be definitively closed in a short period of time may be considered. The lack of prolonged and advanced surgical care renders limb salvage challenging.

PERFORMANCE IMPROVEMENT (PI) MONITORING

POPULATION OF INTEREST

Patients with long-bone fractures of the extremities (femur, tibia, humerus, radius, ulna).

INTENT (EXPECTED OUTCOMES)

1. All patients in the population of interest have a neurovascular exam documented at every role of care.
2. All patients in the population of interest have fractures stabilized (splinted or external fixator placement) prior to transport from the first surgical capability.
3. All patients in the population of interest with an associated vascular injury in the same extremity (i.e. vascular injury associated with fracture) undergo vascular shunt or vascular repair AND external fixation.

PERFORMANCE / ADHERENCE METRICS

1. Patients in the population of interest with a neurovascular exam documented at every level of care.
2. All long-bone extremity fractures that are stabilized by splinting or external fixation prior to movement from a surgical capability.
3. Casualties with fractures and vascular injury in the same extremity (i.e. vascular injury associated with fracture) who underwent vascular shunt or vascular repair also received external fixation.

DATA SOURCE

- Patient Record
- Department of Defense Trauma Registry (DoDTR)

SYSTEM REPORTING & FREQUENCY

The above constitutes the minimum criteria for PI monitoring of this CPG. System reporting will be performed every five years; additional PI monitoring and system reporting may be performed as needed.

The system review and data analysis will be performed by the JTS Chief and the PI Branch.

RESPONSIBILITIES

It is the trauma team leader's responsibility to ensure familiarity, appropriate compliance and PI monitoring at the local level with this CPG.

DOCTRINE, ORGANIZATION, TRAINING, MATERIEL, LEADERSHIP AND EDUCATION, PERSONNEL, FACILITIES, AND POLICY (DOTMLPF-P)

DOTMLPF-p Domain	Implementation Requirements
Doctrine	• Establish this CPG as the standard of care for initial non-surgical and surgical management of extremity fractures. • Integrate protocols with existing TCCC guidelines and prolonged field care CPGs. • Standardize damage control orthopedics, emphasizing early thorough debridement and immediate long-bone stabilization to mitigate systemic physiological decline (e.g., acute respiratory distress syndrome).
Organization	• Ensure Role 2 and Role 3 Medical Treatment Facilities (MTFs) maintain cohesive surgical teams (general and orthopedic surgeons) capable of coordinating simultaneous life- and limb-saving procedures (e.g., vascular shunting combined with external fixation). • Streamline communication and coordination with the Theater Patient Movement Requirements Center (TPMRC) for timely evacuation to definitive care facilities.
Training	• Train deployed medical personnel and general surgeons on austere, non-fluoroscopic external fixator application using the step-by-step guidance provided in Appendix A. • Ensure familiarity with specific portable military external fixation sets (e.g., Stryker Hoffmann 3 Sterile Field Kits). • Conduct sustainment training on recognizing viable tissue ("paprika sign") during debridement and identifying compartment syndrome.
Materiel	• Standardize and stock Class VIII medical materiel (per Appendix B), ensuring adequate supplies of Stryker Field Kits (A & B) with appropriate carbon fiber bars, pins (4mm and 5mm), and clamps. • Maintain supply chains for necessary splinting materials (plaster, fiberglass, traction splints, pelvic binders). • Ensure availability of large-volume sterile irrigation fluids, specific IV antibiotics (e.g., Cefazolin, Ceftriaxone), and topical antibiotic powder (Vancomycin).
Leadership & Education	• Medical directors and trauma team leaders must oversee CPG compliance and ensure continuous PI monitoring and reporting. • Educate operational commanders on the high epidemiological burden of musculoskeletal injuries (which make up the majority of combat surgical workloads) to ensure adequate prioritization of surgical assets and evacuation resources.
Personnel	• Staff Role 2 and Role 3 MTFs with appropriately credentialed surgical providers capable of managing complex, high-energy blast trauma to the extremities. • Ensure appropriate staffing of supporting personnel (e.g., surgical technicians, medics) to assist in serial debridements (every 24-48 hours) and rapid mass casualty interventions.
Facilities	• Ensure austere facilities (Role 2) are equipped with sufficient operating and sterilization capabilities to perform initial pulse-irrigation, debridement, and external fixation. • Ensure Role 3 facilities have the holding capacity and advanced radiographic capabilities required for more definitive soft-tissue and fracture management.
Policy	• Mandate adherence to DoD policies regarding the documentation of "off-label" use of FDA-approved products (as outlined in Appendix D). • Enforce mandatory system reporting and data capture within the DoDTR for specific PI metrics (e.g., neurovascular exams documented, fractures stabilized prior to movement).

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APPENDIX A: EX-FIX GUIDE FOR THE NON-ORTHOPAEDIC SURGEON

The purpose of an external fixator ("ex-fix") is to provide a temporizing measure to hold fractured bones (usually the femur or tibia) in a reasonable position until further surgery can be performed. The ex-fix provides stability to bones, which is particularly important in transfer situations in a combat zone, takes pressure off the surrounding soft tissues and joints, and provides pain relief to the patient.

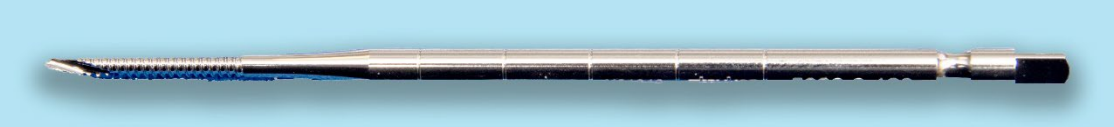
There are two main types of external fixator constructs:

1. Both sets of pins go in the same long bone on either side of the fracture.
2. Joint-spanning external fixator: one set of pins goes in one bone, and the other set goes into the adjacent bone (e.g., knee-spanning external fixator consists of pins in the femur and the tibia). These are typically performed when the fracture occurs near a joint.

The basic construct consists of the following components:

1. **Pins:** stainless steel pins that are drilled into bone, either on power or by hand. The tips of the pins are threaded to prevent them from backing out of bone.
   a. 5mm pins are typically used for the femur and tibia.
   b. The pin's drill tip should be advanced through the bone to ensure full engagement of the threads.

Figure 1



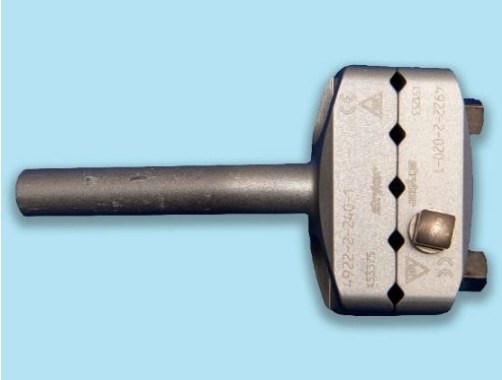
   c. 4mm pins are typically used for the upper extremity and foot. A centrally threaded (trans fixation, Figure 2) pin may be placed through the calcaneus.
2. **Bars:** rods that connect to pins, or to other bars, via clamps. Modern bars are typically made of carbon fiber and have a diameter of 11mm (Figure 3).

Figure 2

Figure 3

3. **Pin connectors (AKA pin clamps or "outriggers**"): blocks that allow two pins to be coupled together and provide an attached connector bar (Figure 4). These contain screws that are tightened to lock the pins into place.

Figure 4. 2x5 hole clamp



4. **Combination bar-to-bar and pin-to-bar clamps:** clamps consisting of two openings, one for each bar or pin (Figure 5). The openings come in 3 sizes – 5mm, 8mm, and 11mm, depending on the size of the instrument they attach to. These either attach the clamp bars to a bar or, if more length is needed on the external fixator, attach two bars to each other. **They can also attach the pins to a bar.**

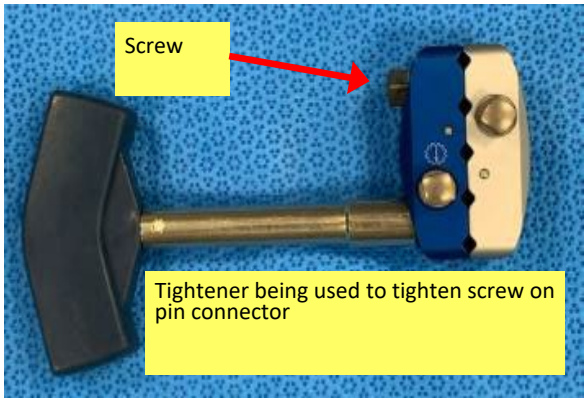
Figure 5. Combi Clamp

Instruments needed to place external fixator:

1. **Scalpel:** Used to make a stab incision for each pin, no greater than 1cm.
2. **Drill:** Can be either a hand drill or powered.
3. **Pin chuck:** May need to be tightened by hand with chuck key depending on system.
4. **Tightener (Figure 6):** Tightens screws on pin connectors and clamps to secure position of pins and bars.

Figure 6. Tightener

Figure 7. Tightener and screw



Sterile Field Kit Components

Commercially available sterile field kits allow for placement of an external fixator by hand and typically consist of the following components:

1. **Scalpel**
2. **Mosquito clamp**
3. **Pins**
4. **Bars**
5. **Manual drill-brace**: Serves dual function as hand drill as well as tightener for clamps; each end is labeled for reference ("pin end" and "clamp).
6. **Bar-to-bar and/or Pin-to-bar clamps**
7. **Pin connectors:** Not available in every kit. May come pre-assembled with angel wing.

Basic principles:

1. Two pins (at least) are required on each end of the fractured bone.
2. Pins should avoid immediate proximity to the fracture site (at least 2-3 fingerbreadths away).
3. The external fixator is a tool to reduce the fractured bone. Try to restore length and gross alignment.

Minimum Supplies: 4 threaded pins, 2 pin connectors ("outriggers"), 2 bars, 2 outrigger bars ("bull horns"; 4 suggested), 4 bar-to-bar clamps. *Note: Fluoroscopy is beneficial but not essential.*

STEP-BY-STEP INSTRUCTIONS

(Associated photos for a knee spanning external fixator)

Pin Placement

1. Identify external fixator pin sites as described above, taking care to remain in safe zones.
   - **Femur:** Anterior or anterolateral
   - **Tibia**: Just medial to anterior tibial crest (ridge)
   - **Calcaneus (heel):** 1-2 fingerbreadths in front of (anterior) and above (proximal) to the posterior corner of the heel. Drill a centrally-threaded pin from medial to lateral to avoid posterior tibial artery.
2. Start either proximal or distal to fracture.
3. Identify 1st pin site; use a scalpel to make a stab incision (7- 10 mm).
4. Use a blunt hemostat to dissect down to bone (keep tips of hemostat closed).
5. Insert pin perpendicular to bone.
   - **Pearl**: To drill the tibial pins, it can be helpful to start drilling perpendicular to the bone and create a divot without going all the way through the cortex, then redirect your hand so it is pointing toward the floor. This may help avoid slippage of the drill.
6. Place pin bicortically—when using a power drill to insert pins be wary of excessive depth of the pin that can damage deep structures. If inserting by hand and/or without power, once the far cortex is engaged (when increased resistance is felt as the pin is turned), advance the pin an additional 6-8 full turns to reach a safe depth. When fluoroscopic imaging is available, placing pins with power is safe and effective. Hand-inserted pins can be adjusted at follow-on facilities when needed.
7. If the pin clamps ("outriggers") are going to be used, slide pin connector over 1st pin to template location of 2nd pin and mark skin with pin or knife. If clamps are not available or desired, placing the pins in any safe location is possible followed by connection to bars with pin-bar or combination clamps.

8. Repeat steps 3-6 for 2nd pin. Placing the pin parallel to the first can reduce the complexity of the fixator, but off-plane pins can increase stability. Pin placement should be decided based on the associated anatomy, fracture and soft tissue injury patterns and fixator stability.
9. Move to proximal (or distal) pin site and repeat steps 1-8.
10. Tighten down the screws securing the pins of the proximal and distal pin connectors, ensuring there are 2-3 finger-breaths between the pin connectors and the skin. This is important because swelling often occurs and may compromise the skin if the skin is too close to the pin connector. Putting the pin connector too far from the skin, however, will decrease the stability of the construct.
11. If fluoroscopy is available, confirm safe, bicortical position of all pins. The drill tip of the pin should be advanced to a depth allowing full engagement of the cortex with the threaded portion of the pin. A few of the threads of the pin should be penetrating through the second cortex.

External fixator Assembly

1. Loosely connect one bar on each pin clamp connector bar both distally and proximally (If there is only one pin clamp connector bar proximally and distally, two clamps can be placed on the same pin clamp connector bar to maximize stability).

Figure 8. 11mm rod with 5-hole pin clamp

Additional bar(s) may need to be placed on each side and connected to the other bars via bar-to-bar clamps for joint-spanning external fixators.

2. Apply longitudinal traction to restore length and correct the coronal and sagittal alignment of the limb ("make the leg look like a leg"). If fluoroscopy is available, the reduction can be optimized, but an anatomic reduction is not required. Bony apposition improves stability but can be difficult to maintain with damage control fixators, and quickly restoring overall alignment without delaying additional treatment or transfer in the acute phase is preferable.
3. Tighten all components.
4. Confirm clinical alignment, as well as radiographic alignment if fluoroscopy is available.
5. Dress pins with petroleum gauze (if desired) and Kerlix wrapping between skin and pin connector.

APPENDIX B: CLASS VIII MEDICAL MATERIEL

Here is a detailed, itemized medical materiel checklist to support implementation of the Joint Trauma System CPG Orthopaedic Trauma: Extremity Fractures (CPG ID: 56)

PREHOSPITAL/FIELD STABILIZATION (SPLINTING/TRANSPORT)

- Pelvic binder (commercial or SAM-style)
- Traction splint (femur)
- Rigid and removable splints:
  - Long-leg splint
  - Below-knee splint/ankle splint
  - Long-arm posterior splint/sugar-tong splint
  - Sling and swathe/coaptation splint for humerus/shoulder
- Padding materials (foam, rolled gauze) for pressure points
- Splint labels/marker to note time/date of debridement and neurovascular checks.

WOUND CARE, IRRIGATION, DEBRIDEMENT & DRESSING

- Sterile irrigation solution (normal saline) large-volume bags and irrigation syringes (60 mL).
- Sterile OR irrigation tubing/splash shields.
- Sterile dressings: bulky dressings, non-adherent dressings, ABD pads (multiple sizes).
- Sterile towels, drapes.
- Sterile bowls / basins for irrigation and instrument prep.
- Surgical suction tubing if available.

ANTIBIOTICS, TETANUS, AND OTHER MEDICATIONS

- Appropriate antibiotics (see above)
- Alternative IV antibiotic (e.g., clindamycin) for allergy
- Additional Gram-negative coverage if indicated
- Tetanus toxoid/tetanus immunoglobulin (as indicated) stock.
- Analgesics & sedation: IV opiates, ketamine, procedural sedation agents as per capability.
- Local anesthetic (e.g., lidocaine) and nerve-block supplies if used.
- IV fluids and resuscitation supplies.

EXTERNAL FIXATION

- Minimum supplies (CPG):
  - 4 threaded pins (appropriate diameters: e.g., 5 mm for femur/tibia; 4 mm for upper extremity/foot).
  - 2 pin connectors.
  - 2 bars (connecting rods).
  - 2 angel wings (posts)
  - 4 bar-to-bar clamps.
- Additional/recommended ex-fix components:
  - Pin-to-bar clamps.
  - Extra bars/bar-to-bar connectors.
  - Extra pins (various diameters: 4 mm, 5 mm, centrally threaded calcaneal pins if needed).
  - Bar-to-bar connector clamps and spare screws.

EXTERNAL FIXATION - INSTRUMENTS REQUIRED

- Scalpel handles and blades (sterile).
- Mosquito hemostats/small clamps.
- Drill (power drill if available) or manual hand-drill / brace (manual drill-brace recommended in sterile field kits).
- Pin chuck (with chuck key if applicable).
- Hand tightener/screwdriver/wrench for clamp screws (tightener tool).
- Sterile measuring ruler (for pin depth) and markers.
- Sterile blunt hemostats for blunt dissection to bone.
- Sterile irrigation syringes and suction.
- Sterile needle drivers, forceps, scissors.
- Sterile drapes, gowns, gloves.

Sterile Field Kit Components (Commercial Kits or Assembled Set)

- Scalpel.
- Mosquito clamp.
- Pins.
- Bars.
- Manual drill-brace (dual function: hand drill and clamp tightener).
- Bar-to-bar and/or pin-to-bar clamps.
- Pin connectors (may be pre-assembled with angel wing).
- Sterile towels/drapes and instrument tray.

Casting/Splinting Materials (Definitive/Temporary Immobilization)

- Plaster rolls (plaster of Paris) several rolls
- Fiberglass casting material - multiple rolls.
- Padding rolls (stockinette, cotton under wrap).
- Cast saw (if available) and cast removal supplies.
- Cast padding and cast-cutting equipment.

Traction & Specialty Devices

- Skeletal traction setup (pins, weights, trolleys) if available and indicated.
- Traction splint (commercial) for femur fractures.

Vascular/Neurovascular Adjuncts & Fasciotomy Tools

- Vessel loops, vascular clamps, small-bore vascular instruments).
- Doppler handheld (for distal flow checks) if available.
- Instruments for fasciotomy (scalpels, retractors).

Hemostasis & Irrigation Tools

- Electrocautery unit and sterile cautery tips.
- Large-volume irrigation (15–30 L syringe setups or pressure irrigation systems).
- Suction tubing and canisters

Suture, Fixation, Wound Closure & Topical Agents

- Variety of suture sizes (absorbable and non-absorbable), sterile needles.
- Skin staples and staplers.
- Wound vac supplies.
- Topical antibiotics / antibiotic beads. The CPG notes topical agents are increasingly used.

Sterility/PPE/Consumables

- Surgical masks, eye protection, sterile gowns, sterile gloves (multiple sizes).
- Sterile drapes, bowl covers.
- Antiseptic solutions (chlorhexidine, povidone-iodine).
- Sharps containers.
- Sterile specimen containers.
- Sterile towels and linen.

Imaging/Documentation/Monitoring

- Portable X-ray capability.
- Radiograph markers and protective equipment.
- Neurovascular exam forms/documentation templates

Consumable Hardware Spares & Kit Maintenance

- Extra screws/small hardware for clamps.
- Spare pins and connectors
- Spare drill bits and batteries for power drill.
- Sterile resealable packs for unused components.

For additional information including National Stock Number (NSN), please contact dha.ncr.med-log.list.lpr-cps@health.mil

***DISCLAIMER**: This is not an exhaustive list. These are items identified to be important for the care of combat casualties.*

APPENDIX C: TELECONSULTATION / TELEMEDICINE

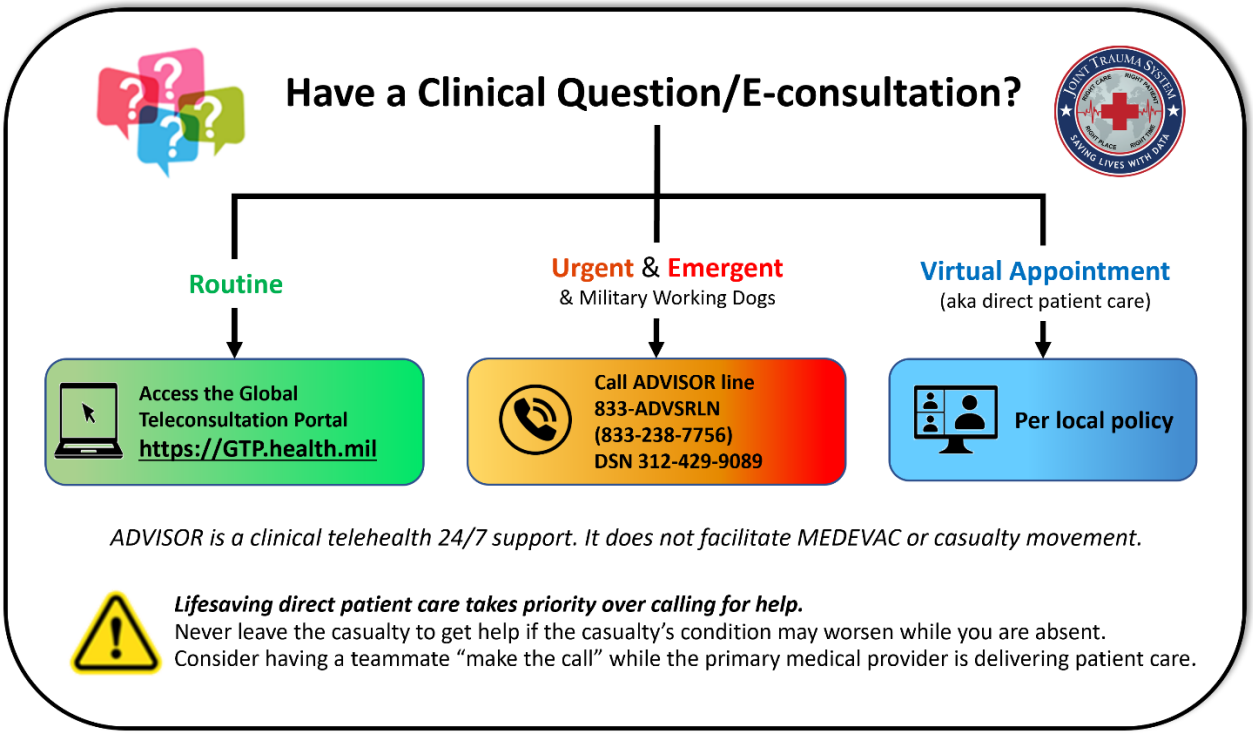


Illustration by Raymond Samonte

***GTP**: https://GTP.health.mil*

Theater Patient Movement Requirements Center (TPMRC): to coordinate evacuation

- *TPMRC - Americas (NORTHCOM & SOUTHCOM), 618-817-4200*
- *TPMRC - East (EUCOM, AFRICOM, CENTCOM), DSN 314-480-8040*
- *TPMRC - West (INDOPACOM), DSN 315-448-1062*

APPENDIX D: INFORMATION REGARDING OFF-LABEL USES IN CPGS

PURPOSE

The purpose of this Appendix is to ensure an understanding of DoD policy and practice regarding inclusion in CPGs of "off-label" uses of U.S. Food and Drug Administration (FDA)–approved products. This applies to off-label uses with patients who are members of the Armed Forces.

BACKGROUND

Unapproved (i.e. "off-label") uses of FDA-approved products are extremely common in American medicine and are usually not subject to any special regulations. However, under Federal law, in some circumstances, unapproved uses of approved drugs are subject to FDA regulations governing "investigational new drugs." These circumstances include such uses as part of clinical trials, and in the military context, command required, unapproved uses. Some command requested unapproved uses may also be subject to special regulations.

ADDITIONAL INFORMATION REGARDING OFF-LABEL USES IN CPGS

The inclusion in CPGs of off-label uses is not a clinical trial, nor is it a command request or requirement. Further, it does not imply that the Military Health System requires that use by DoD health care practitioners or considers it to be the "standard of care." Rather, the inclusion in CPGs of off-label uses is to inform the clinical judgment of the responsible health care practitioner by providing information regarding potential risks and benefits of treatment alternatives. The decision is for the clinical judgment of the responsible health care practitioner within the practitioner-patient relationship.

ADDITIONAL PROCEDURES

Balanced Discussion

Consistent with this purpose, CPG discussions of off-label uses specifically state that they are uses not approved by the FDA. Further, such discussions are balanced in their presentation of appropriate clinical study data, including any data that suggest caution in the use of the product and any FDA-issued warnings.

Quality Assurance Monitoring

With respect to such off-label uses, DoD procedure is to maintain a regular system for quality-assurance monitoring of outcomes and known potential adverse events. For this reason, the importance of accurate clinical records is underscored.

Information to Patients

Good clinical practice includes providing appropriate information to patients. Each CPG discussing an unusual off-label use will address the issue of information to be provided to patients. When practicable, consideration will be given to including in an appendix an appropriate information sheet for distribution to patients, whether before or after use of the product. Information to patients should address in plain language: a) that the use is not approved by the FDA; b) the reasons why a DoD health care practitioner would decide to use the product for this purpose; and c) the potential risks associated with such use.