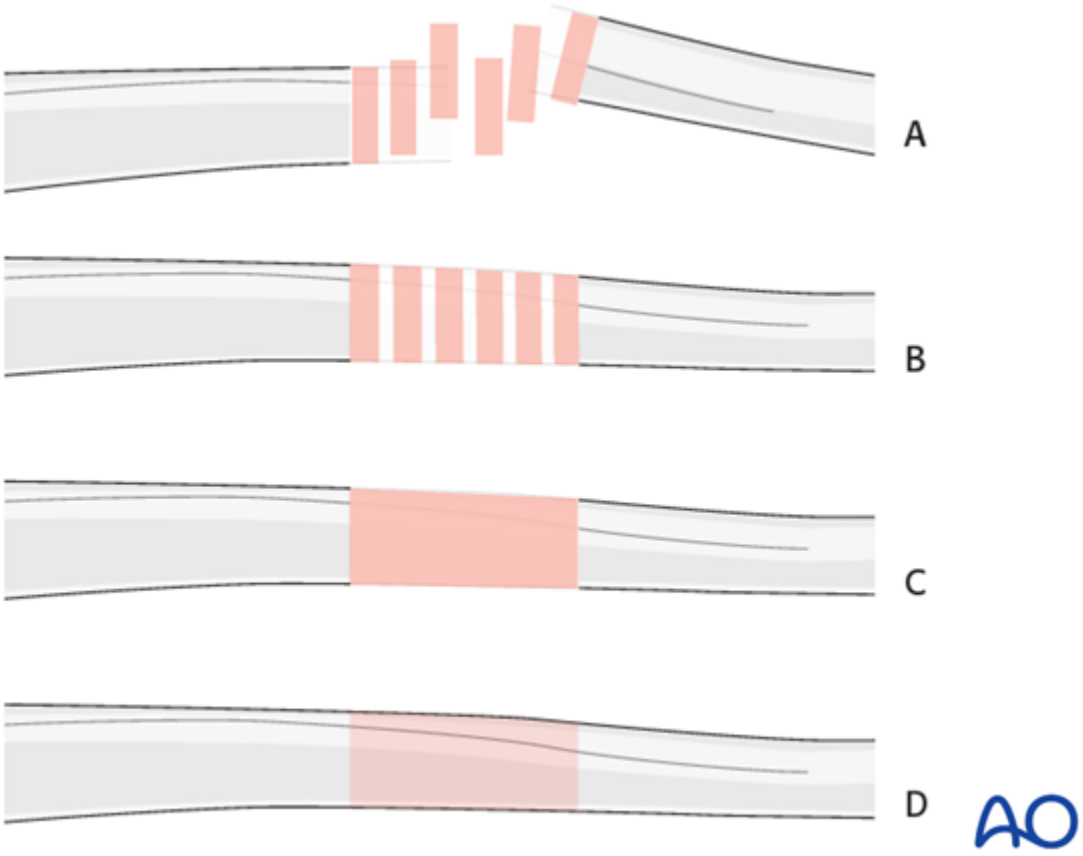
Note on illustrations

Throughout this treatment option illustrations of generic fracture patterns are shown, as four different types:

A) Unreduced fracture
B) Reduced fracture
C) Fracture reduced and fixed provisionally
D) Fracture fixed definitively

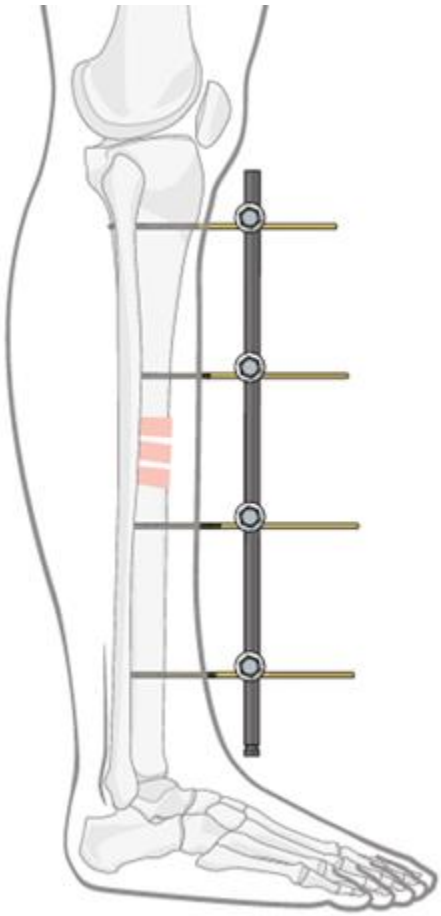


2. Principles of uniplanar external fixation

The frame of a uniplanar external fixator consists of at least two pins in each main fracture fragment connected with one single rod. A second rod may be added to increase stiffness of the frame.

Details of external fixation are described in the **basic technique for application of modular external fixator**.

Specific considerations for the uniplanar external fixator in the tibial shaft are given below.

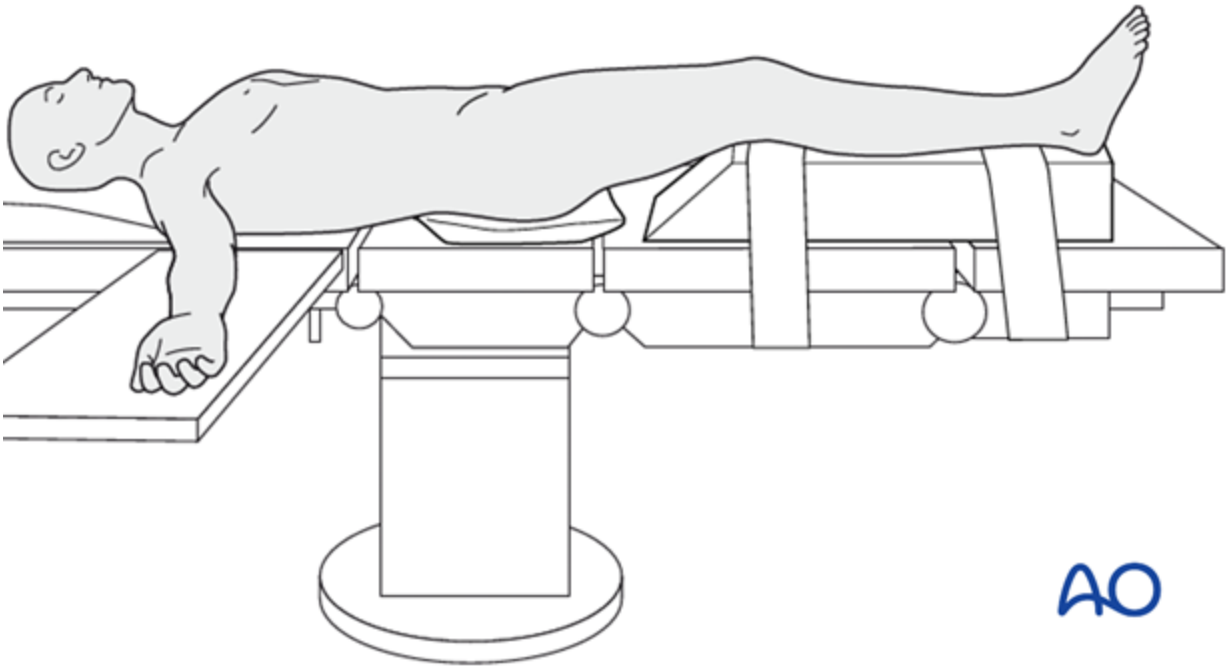


Teaching video

AO teaching video: Uniplanar double-rod frame

3. Patient preparation

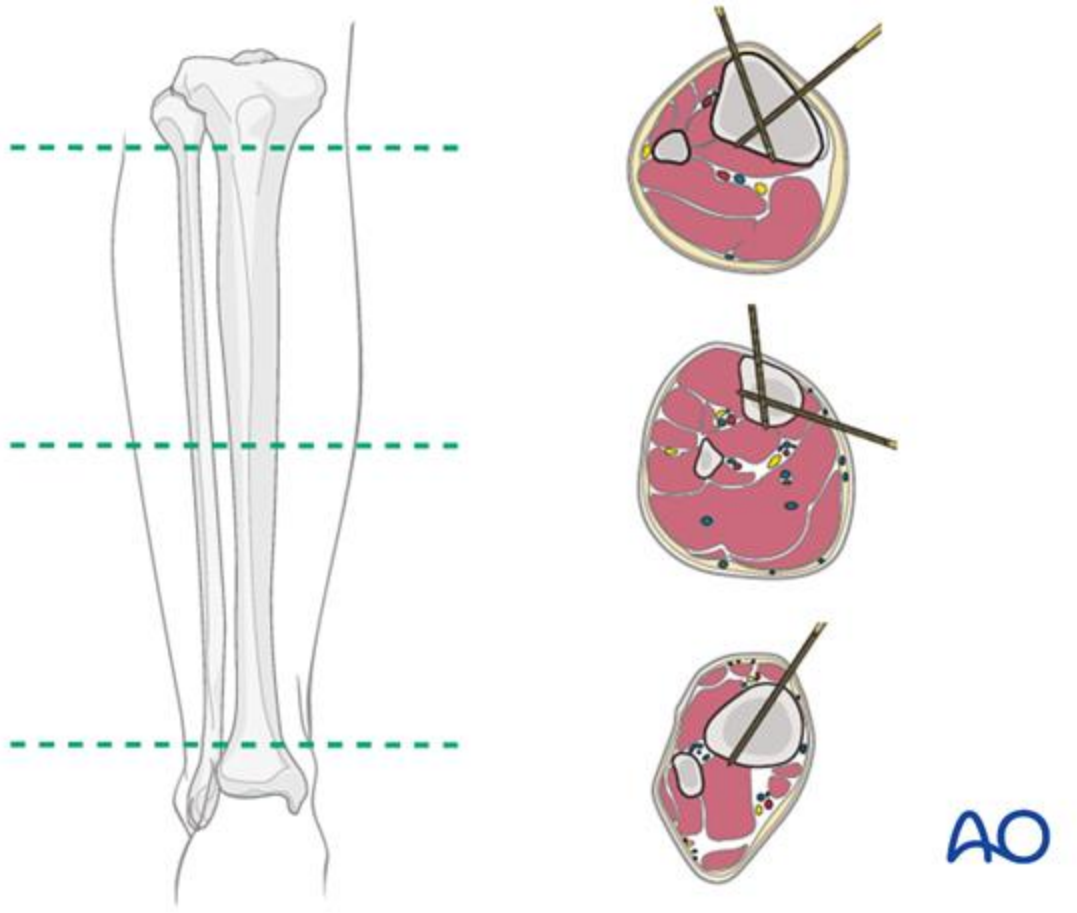
This procedure is normally performed with the patient in a **supine position**.



4. Safe zones for pin placement

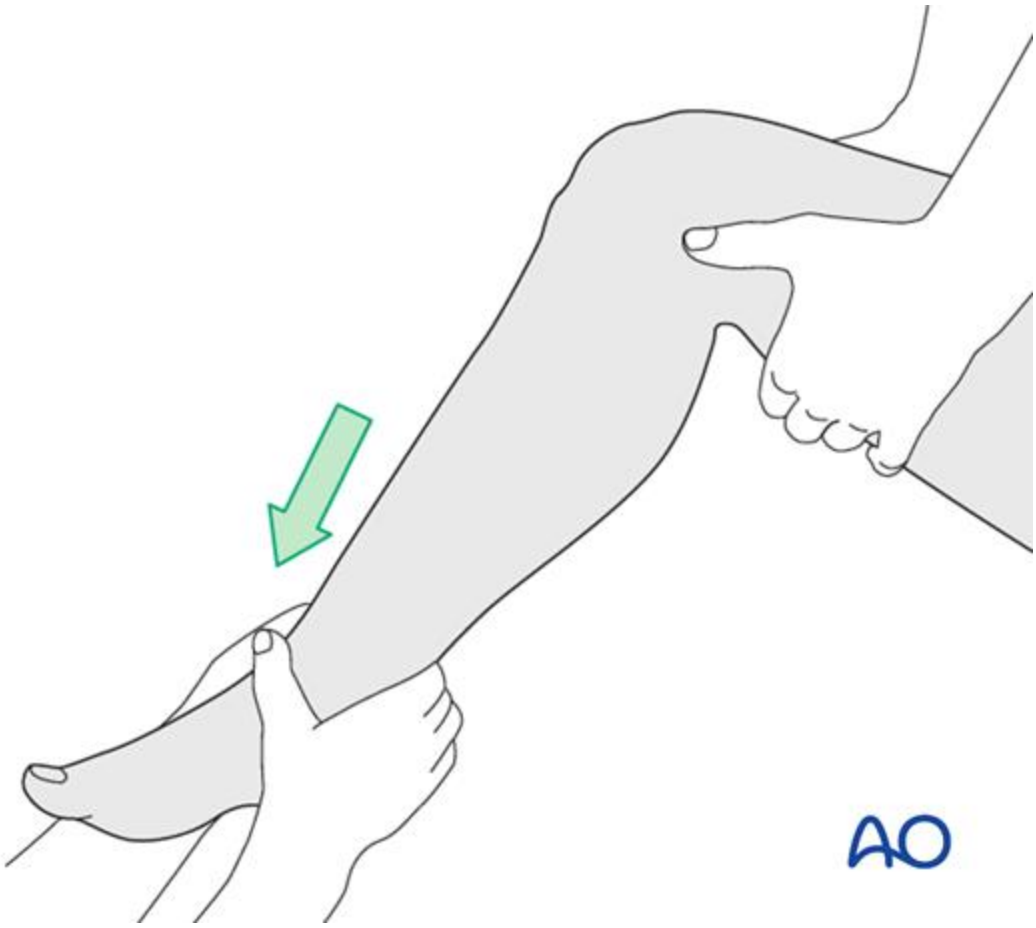
For safe pin placement make use of the **safe zones** and be familiar with the anatomy of the lower leg.

Pearl
The pin in the distal tibia should be placed far away from the extensor tendons on the medial side.



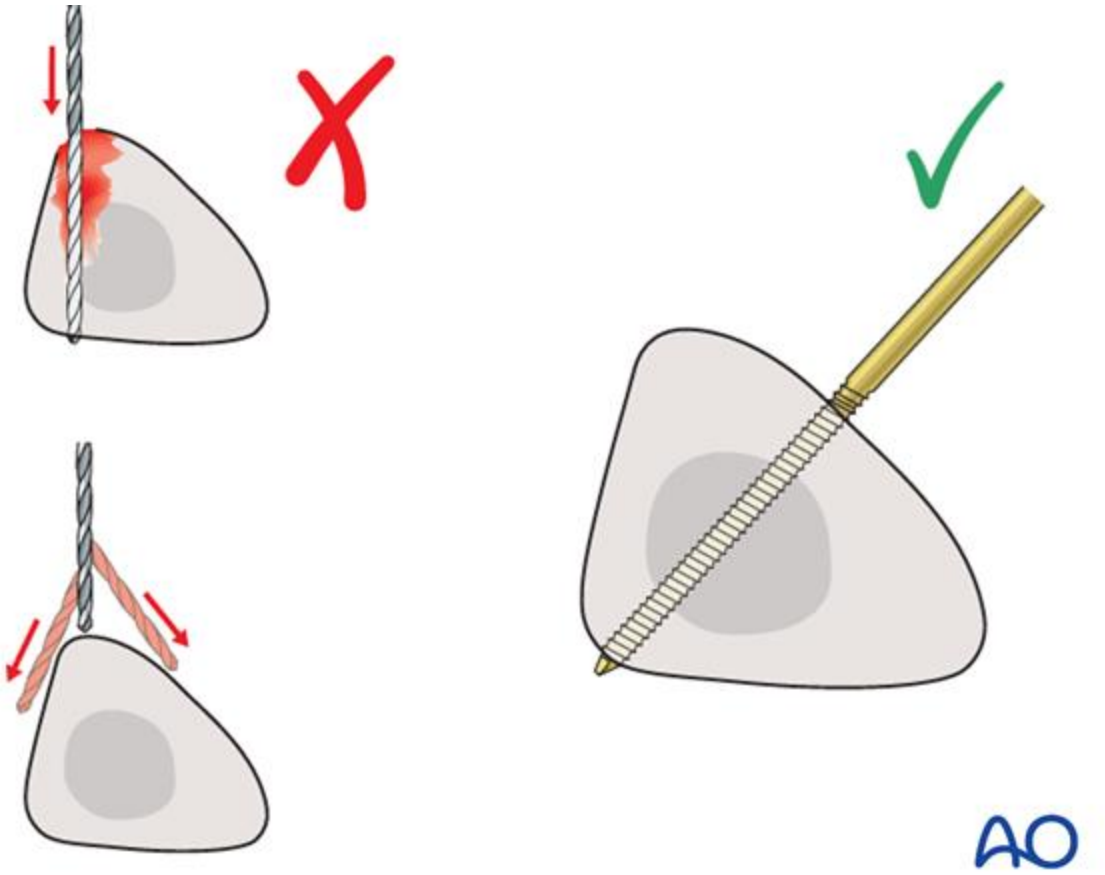
5. Reduction (tibial shaft)

Apply manual longitudinal traction to leg and maintain reduction.



6. Pin insertion (tibial shaft)

Drilling a hole in the thick tibial crest may be associated with excessive heat generation and there is a risk the drill bit may slip medially or laterally damaging the soft tissues. As the anteromedial tibial wall provides adequate thickness for the placement of pins, this trajectory is preferable. A trajectory angle (relative to the sagittal plane) of 20-60° for the proximal fragment and of 30-90° for the distal fragment is recommended.



7. Frame construction / fixation (tibial shaft)

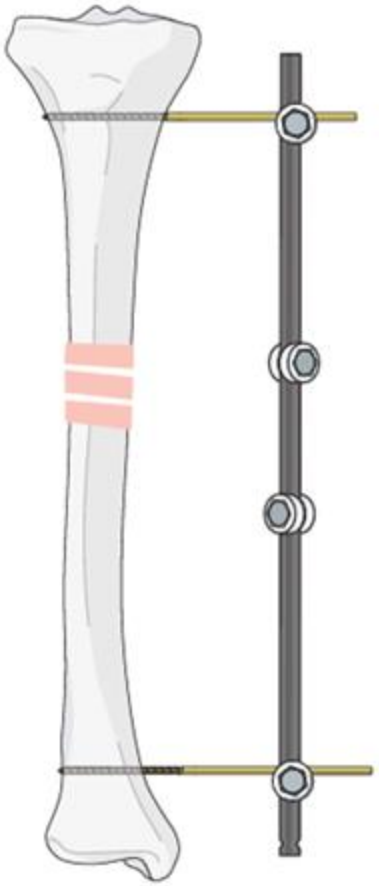
Pin insertion and frame assembly

Insert a pin into each main fragment in one plane.

Connect the pins with one rod to which 4 clamps have been added.

At this point, some correction to the reduction is still possible.

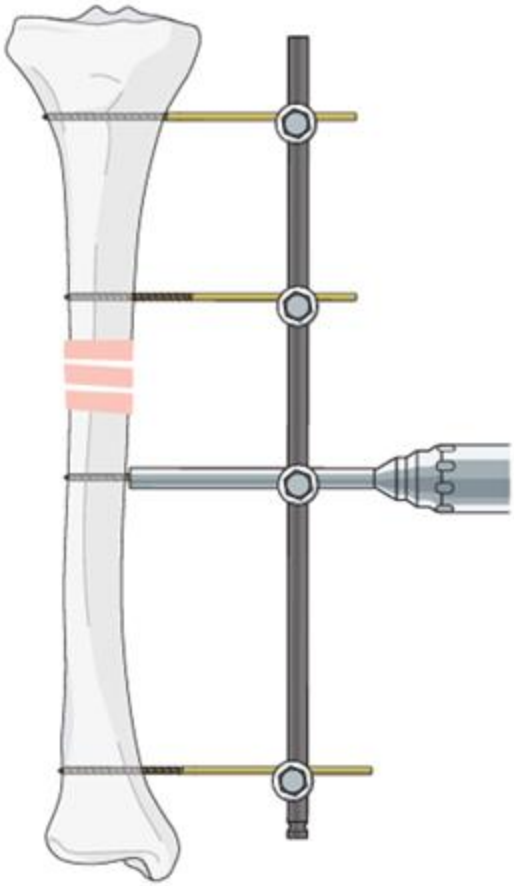
Tighten the clamps.



On both sides of the fracture, add an additional pin close to the fracture zone using the rod-to-pin clamps as guides.

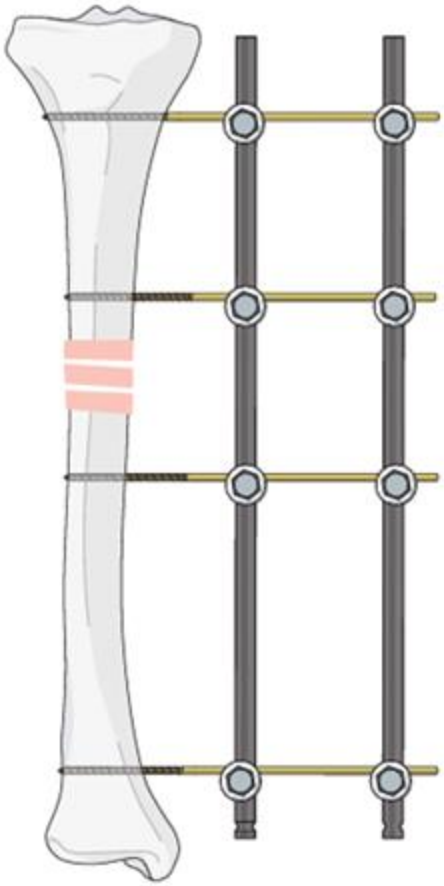
Tighten the clamps.

Subsequent correction of the reduction is now impossible.



Additional rod

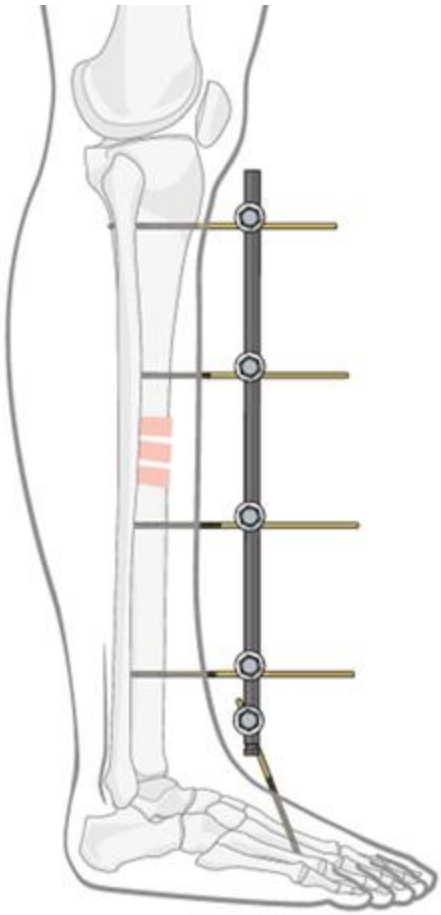
If stability is not sufficient, an additional rod can be added. The stiffness of the construct is increased if the rods are closer to the bone, and the further apart from each other the rods are placed.



Pearl: Prevent plantar flexion contracture

In patients with severe soft-tissue involvement, it may be helpful to add a pin in the foot (one of the tarsal or metatarsal bones) to maintain the ankle at a 90° angle. Thereby a plantar flexion contracture can be prevented.

The pin may be inserted in either the navicular bone, in one of the cuneiforms, in the first metatarsal base, or in the first and fifth metatarsal base, and connected to the tibial external fixator. Care should be taken to insert the pin bicortically and to avoid the intra-articular spaces.



8. Aftercare following external fixation

Pin-site care

Proper pin insertion
To prevent postoperative complications, pin-insertion technique is more important than any pin-care protocol:

- Correct placement of pins (see safe zones) avoiding ligaments and tendons, eg tibia anterior
- Correct insertion of pins (eg trajectory, depth) avoiding heat necrosis
- Extending skin incisions to release soft-tissue tension around the pin insertion (see inspection and treatment of skin incisions)

Pin-site care
Various aftercare protocols to prevent pin tract infection have been established by experts worldwide. Therefore no standard protocol for pin-site care can be stated here. Nevertheless, the following points are recommended:

- The aftercare should follow the same protocol until removal of the external fixator.

- The pin-insertion sites should be kept clean. Any crusts or exudates should be removed. The pins may be cleaned with saline and/or disinfectant solution/alcohol. The frequency of cleaning depends on the circumstances and varies from daily to weekly but should be done in moderation.
- No ointments or antibiotic solutions are recommended for routine pin-site care.
- Dressings are not usually necessary once wound drainage has ceased.
- Pin-insertion sites need not be protected for showering or bathing with clean water.
- The patient or the carer should learn and apply the cleaning routine.

Pin loosening or pin tract infection
In case of pin/wire loosening or pin tract infection, the following steps need to be taken:

- Remove all involved pins and place new pins in a healthy location.
- Debride the pin sites in the operating theater, using curettage and irrigation.
- Take specimens for a microbiological study to guide appropriate antibiotic treatment if necessary.

Before changing to a definitive internal fixation an infected pin tract needs to heal. Otherwise infection will result.

Mobilization

Unless there are other injuries or complications, mobilization may be performed on day 1. Static quadriceps exercises with passive range of motion of the knee should be encouraged. Early active range of motion of knee and ankle is encouraged.

The goal of early active and passive range of motion is to achieve a full range of motion within the first 4-6 weeks. Maximum stability is achieved at the time of surgery. A delay beyond a few days to allow swelling to subside is illogical and harmful.

Weight bearing

If external fixation is considered as the definitive device, weight bearing should be encouraged early. The timing and how much weight may be taken through the fracture will be influenced by:

- Patient factors
- Fracture configuration
- Stability of the fixator construct

As soon as callus formation is visible and once there are no clinical signs of instability, the patient can start to bear full weight. After removal of the external fixator, it may be prudent to protect the leg temporarily in a splint or brace.

Follow up

See patient 7-10 days after surgery for a wound check. X-rays are taken to check the reduction.

The patient should be seen every 4-6 weeks in follow-up with examination and x-rays until union is secure, and range of motion and strength have returned.
Inspection of external fixators every two weeks is optional.

Modular external fixator

Share

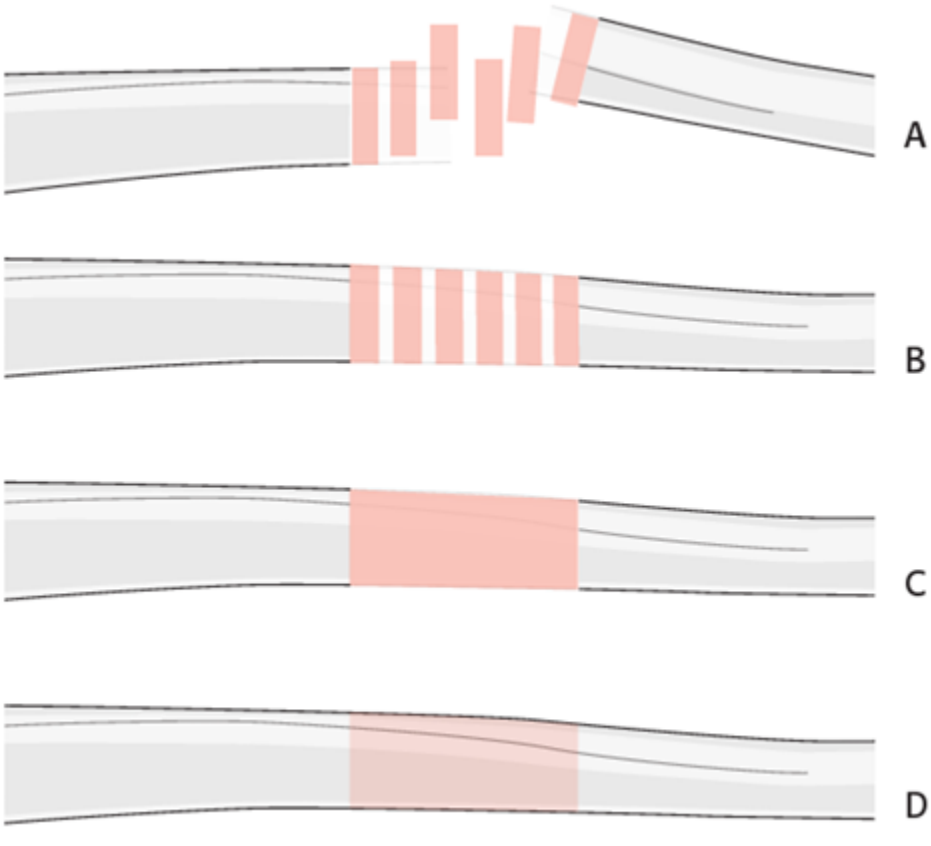
Multifragmentary fracture, intact segmental

7/7 – Aftercare following external fixation

1. Note on illustrations

Throughout this treatment option illustrations of generic fracture patterns are shown, as four different types:

A) Unreduced fracture
B) Reduced fracture
C) Fracture reduced and fixed provisionally
D) Fracture fixed definitively

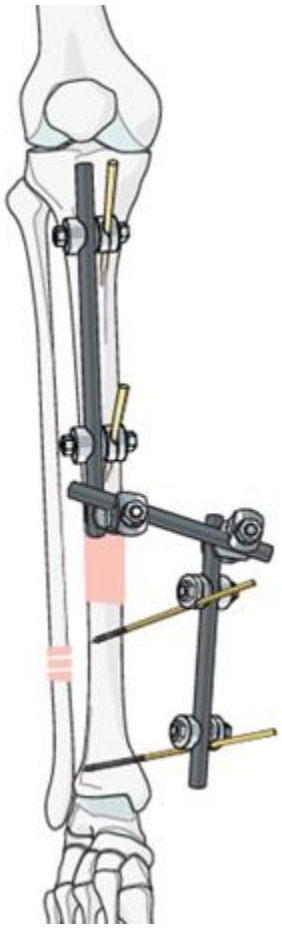


2. Principles of modular external fixation

The modular external fixator is optimal for temporary use. It is rapidly applied without need for intraoperative x-rays and can be adjusted later.

Details of external fixation are described in the **basic technique for application of modular external fixator**.

Specific considerations for the tibial shaft are given below.

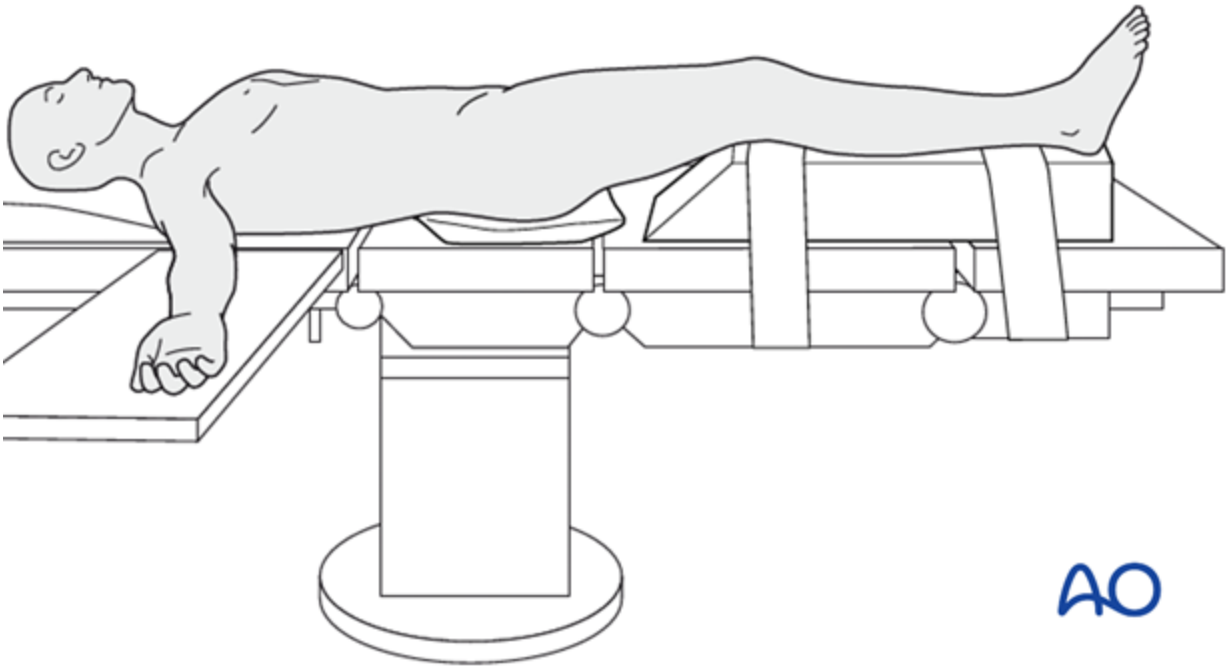


Teaching video

AO teaching video: Modular external fixator

3. Patient preparation

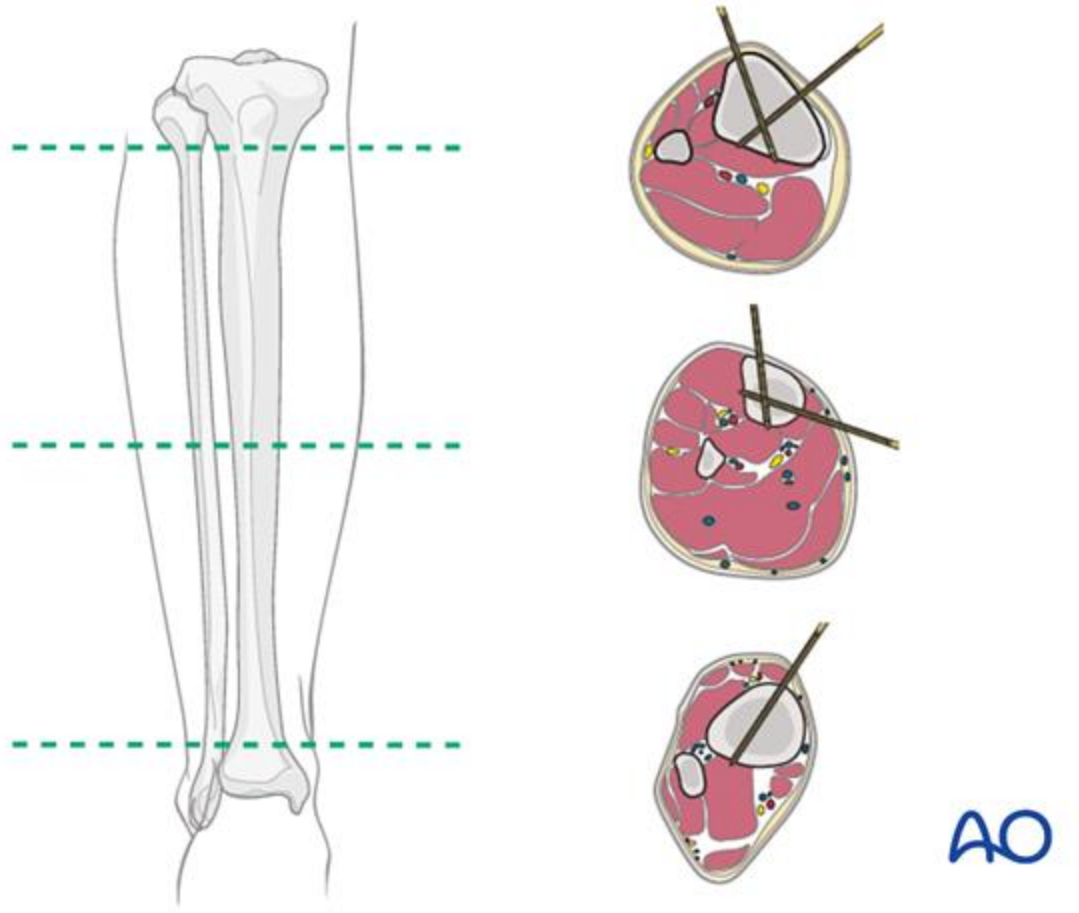
This procedure is normally performed with the patient in a **supine position**.



4. Safe zones for pin placement

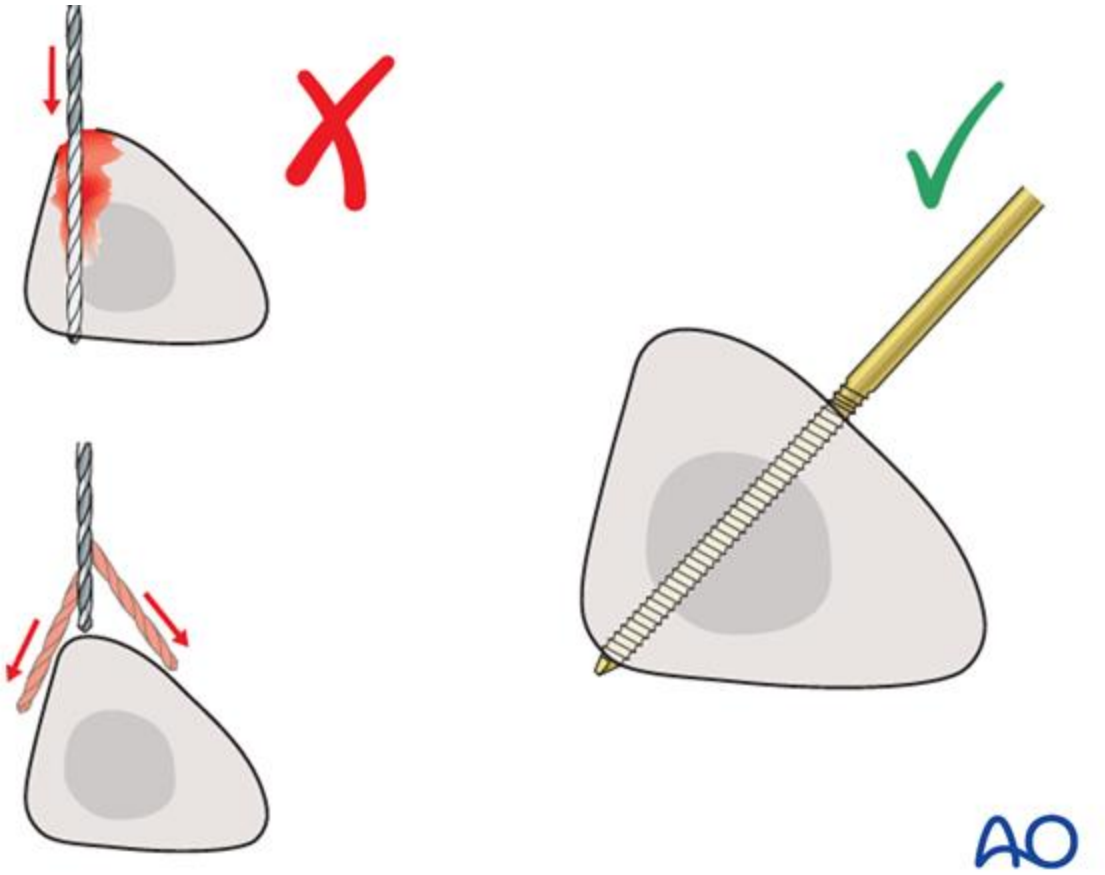
For safe pin placement make use of the **safe zones** and be familiar with the anatomy of the lower leg.

Pearl
The pin in the distal tibia should be placed far away from the extensor tendons on the medial side.

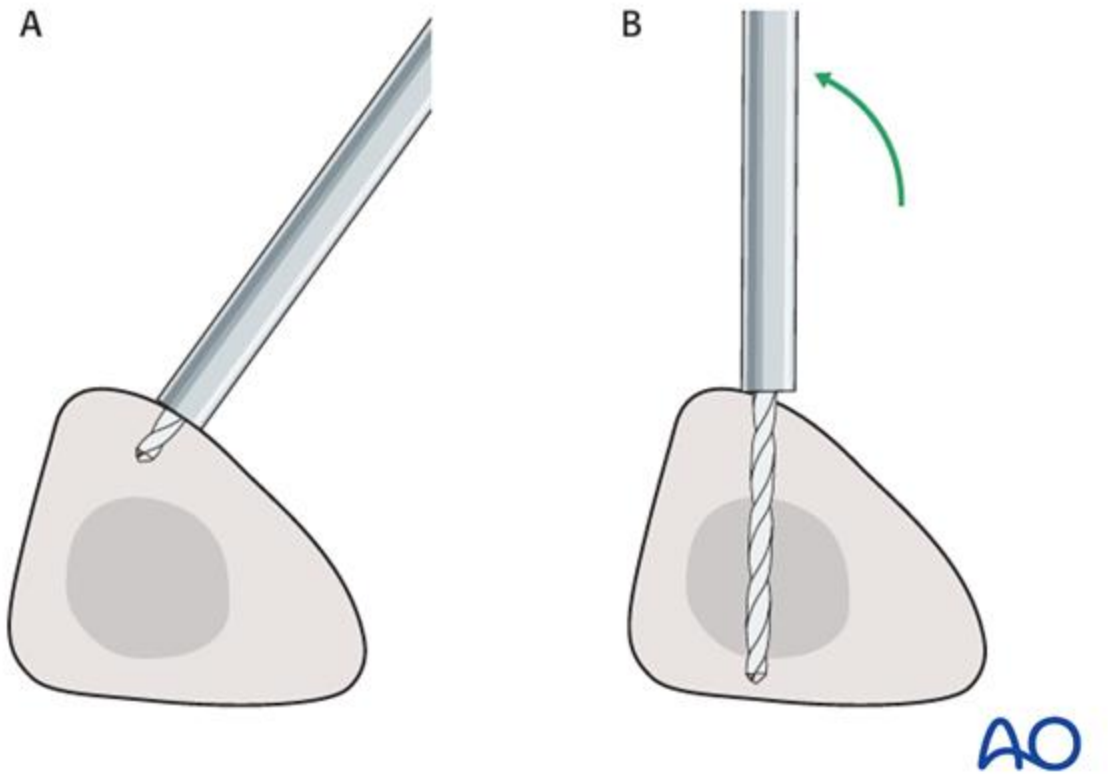


5. Pin insertion (tibial shaft)

Drilling a hole in the thick tibial crest may be associated with excessive heat generation and there is a risk the drill bit may slip medially or laterally damaging the soft tissues. As the anteromedial tibial wall provides adequate thickness for the placement of pins, this trajectory is preferable. A trajectory angle (relative to the sagittal plane) of 20-60° for the proximal fragment and of 30-90° for the distal fragment is recommended.



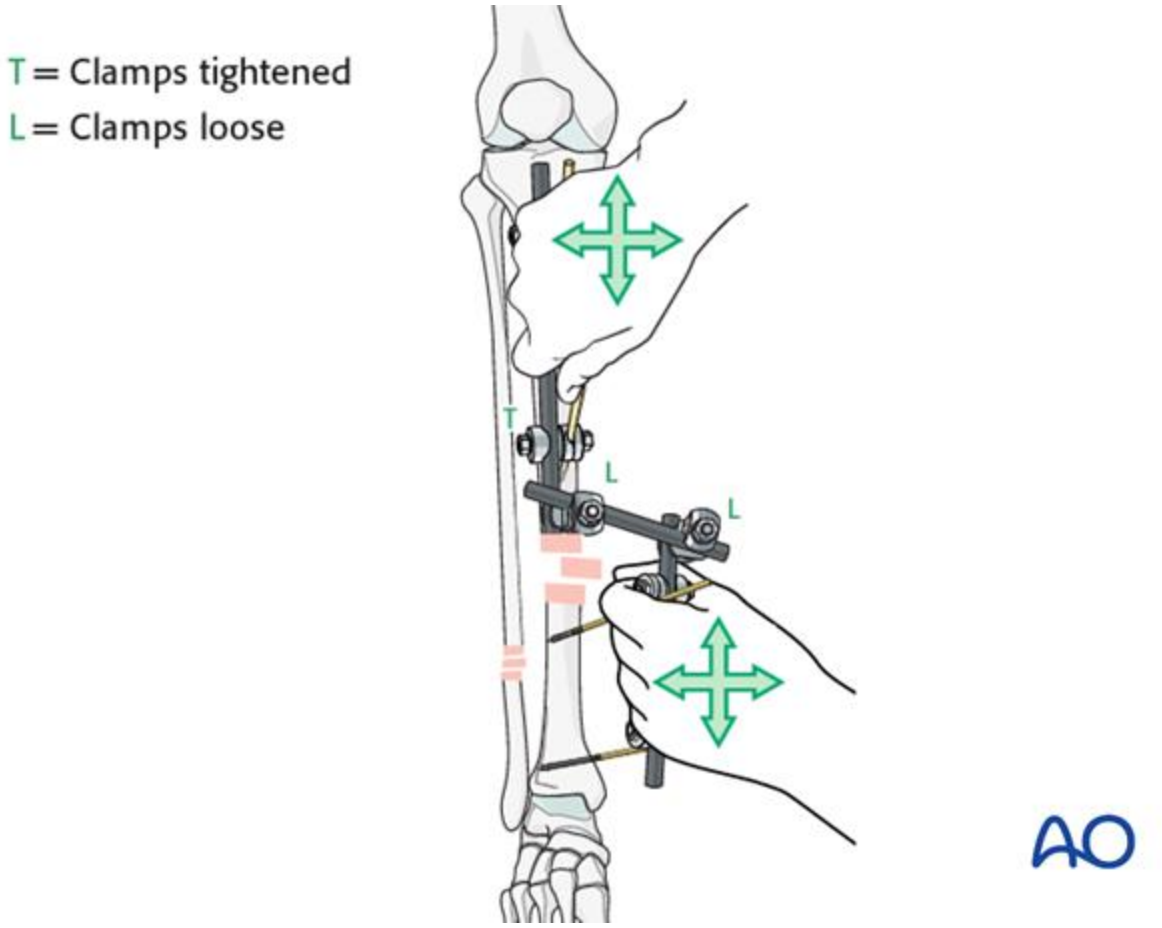
Alternatively, in order to avoid the frame catching on the opposite leg, the pins may be placed more anteriorly. The drill bit is started with the tip just medial to the anterior crest, and with the drill bit perpendicular to the anteromedial surface (A). As the drill bit starts to penetrate the surface, the drill is gradually moved more anteriorly until the drill bit is in the desired plane (B). This should prevent the tip from sliding down the medial or lateral surface.



6. Frame construction / reduction and fixation (tibial shaft)

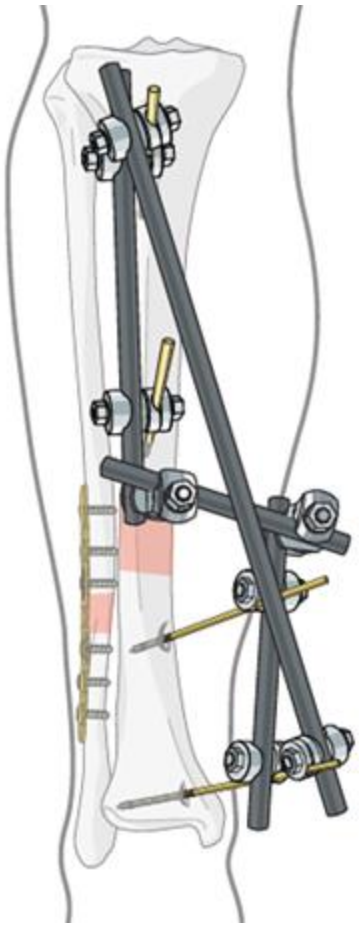
Reduction and fixation

Restore length with a bolster behind the knee to give slight flexion.



Plating of the fibula

In order to add further stability to the reduction, a fractured fibula may be plated.



Pearl: Prevent plantar flexion contracture

In patients with severe soft-tissue involvement, it may be helpful to add a pin in the foot (one of the tarsal or metatarsal bones) to maintain the ankle at a 90° angle and prevent a plantar flexion contracture.

The pin may be inserted in either the navicular bone, in one of the cuneiforms, in the first metatarsal base, or in the first and fifth metatarsal base, and connected with a rod to the tibial external fixator. Care should be taken to insert the pin bicortically and to avoid the intra-articular spaces.

7. Aftercare following external fixation

Pin-site care

Proper pin insertion
To prevent postoperative complications, pin-insertion technique is more important than any pin-care protocol:

- Correct placement of pins (see safe zones) avoiding ligaments and tendons, eg tibia anterior
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Pin loosening or pin tract infection
In case of pin/wire loosening or pin tract infection, the following steps need to be taken:

- Remove all involved pins and place new pins in a healthy location.
- Debride the pin sites in the operating theater, using curettage and irrigation.
- Take specimens for a microbiological study to guide appropriate antibiotic treatment if necessary.

Before changing to a definitive internal fixation an infected pin tract needs to heal. Otherwise infection will result.

Mobilization

Unless there are other injuries or complications, mobilization may be performed on day 1. Static quadriceps exercises with passive range of motion of the knee should be encouraged. Early active range of motion of knee and ankle is encouraged.

The goal of early active and passive range of motion is to achieve a full range of motion within the first 4-6 weeks. Maximum stability is achieved at the time of surgery. A delay beyond a few days to allow swelling to subside is illogical and harmful.

Weight bearing

If external fixation is considered as the definitive device, weight bearing should be encouraged early. The timing and how much weight may be taken through the fracture will be influenced by:

- Patient factors
- Fracture configuration
- Stability of the fixator construct

As soon as callus formation is visible and once there are no clinical signs of instability, the patient can start to bear full weight. After removal of the external fixator, it may be prudent to protect the leg temporarily in a splint or brace.

Follow up

See patient 7-10 days after surgery for a wound check. X-rays are taken to check the reduction.

The patient should be seen every 4-6 weeks in follow-up with examination and x-rays until union is secure, and range of motion and strength have returned.
Inspection of external fixators every two weeks is optional.

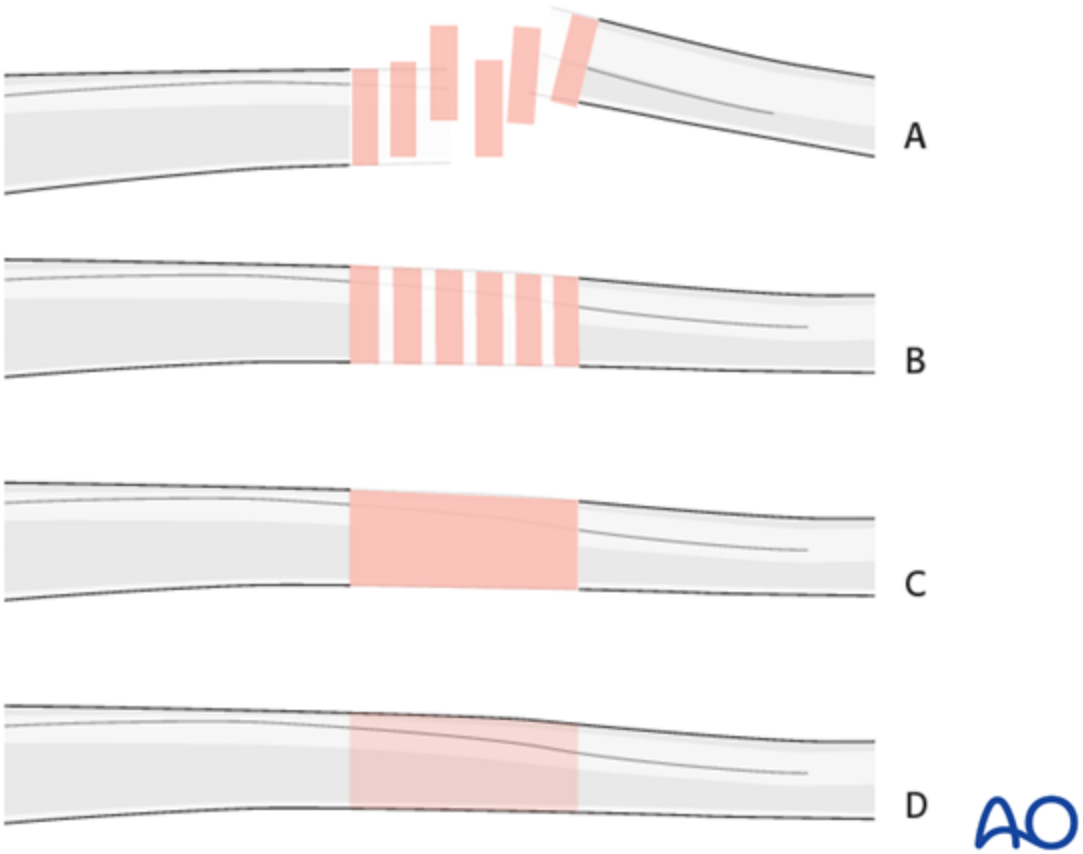
Wedge, fragmentary, middle 1/3 fractures

7/7 – Aftertreatment following temporary external fixation

1. Note on illustrations

Throughout this treatment option illustrations of generic fracture patterns are shown, as four different types:

A) Unreduced fracture
B) Reduced fracture
C) Fracture reduced and fixed provisionally
D) Fracture fixed definitively

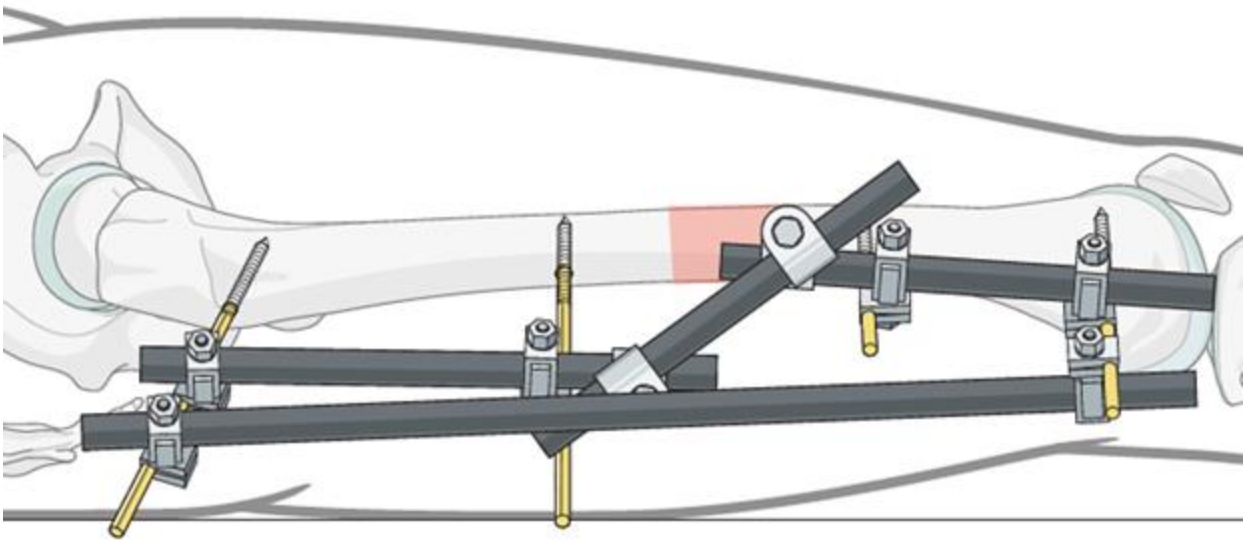


2. Principles of modular external fixation

The modular external fixator is optimal for temporary use. It is rapidly applied without need for intraoperative x-rays and can be adjusted later. If possible the external fixation should be converted to a nail or plate within a week or two, before pin sites become infected. Ensure adequate pin care treatment until frame removal.

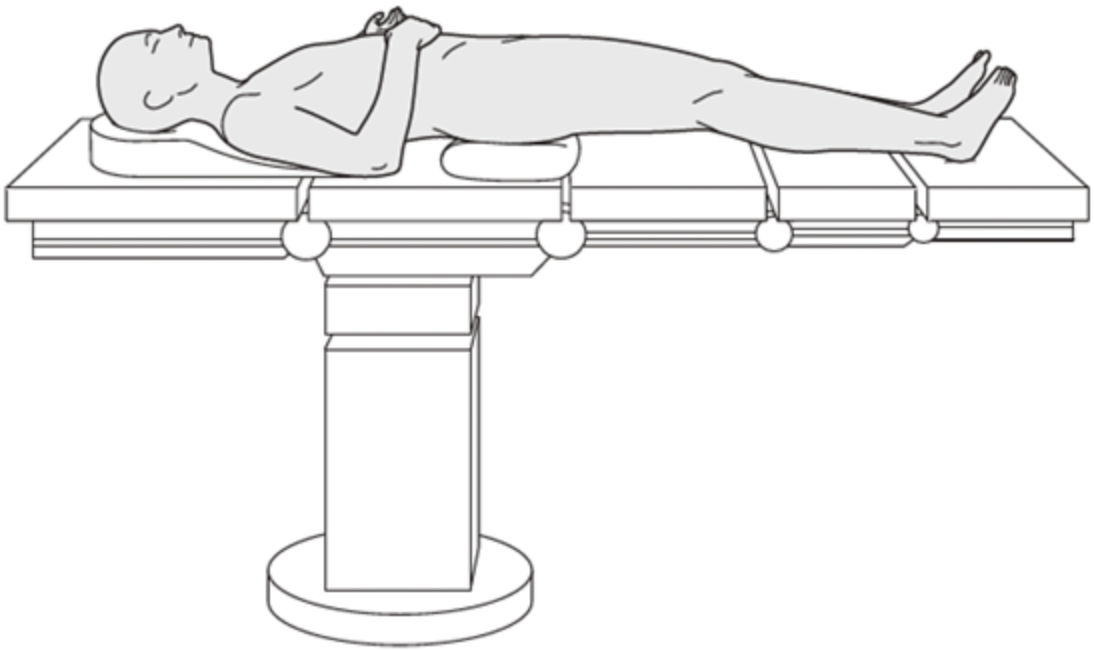
Details of external fixation are described in the **basic technique for application of modular external fixator**.

Specific considerations for the femur are given below.



3. Patient preparation

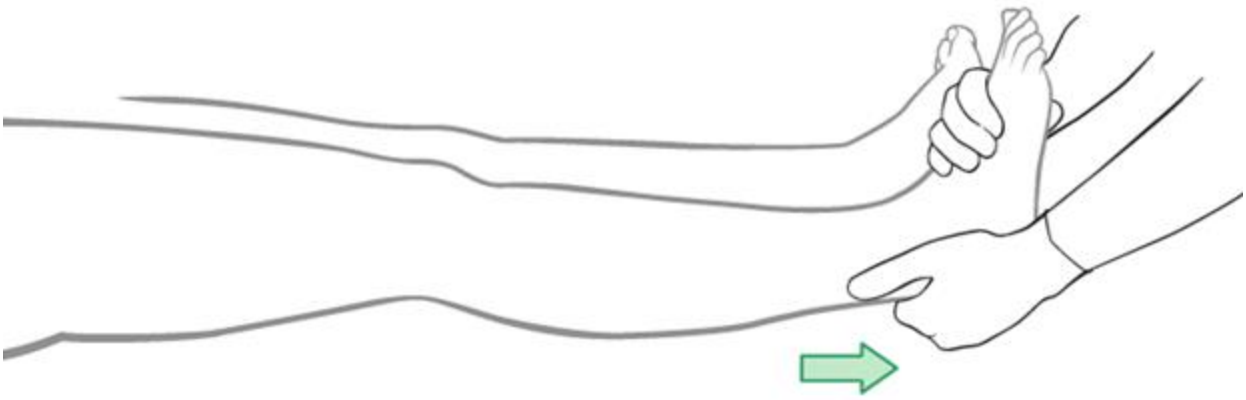
This procedure is normally performed with the patient in a **supine position with manual traction**.



4. Pin insertion (femoral shaft)

Initial reduction

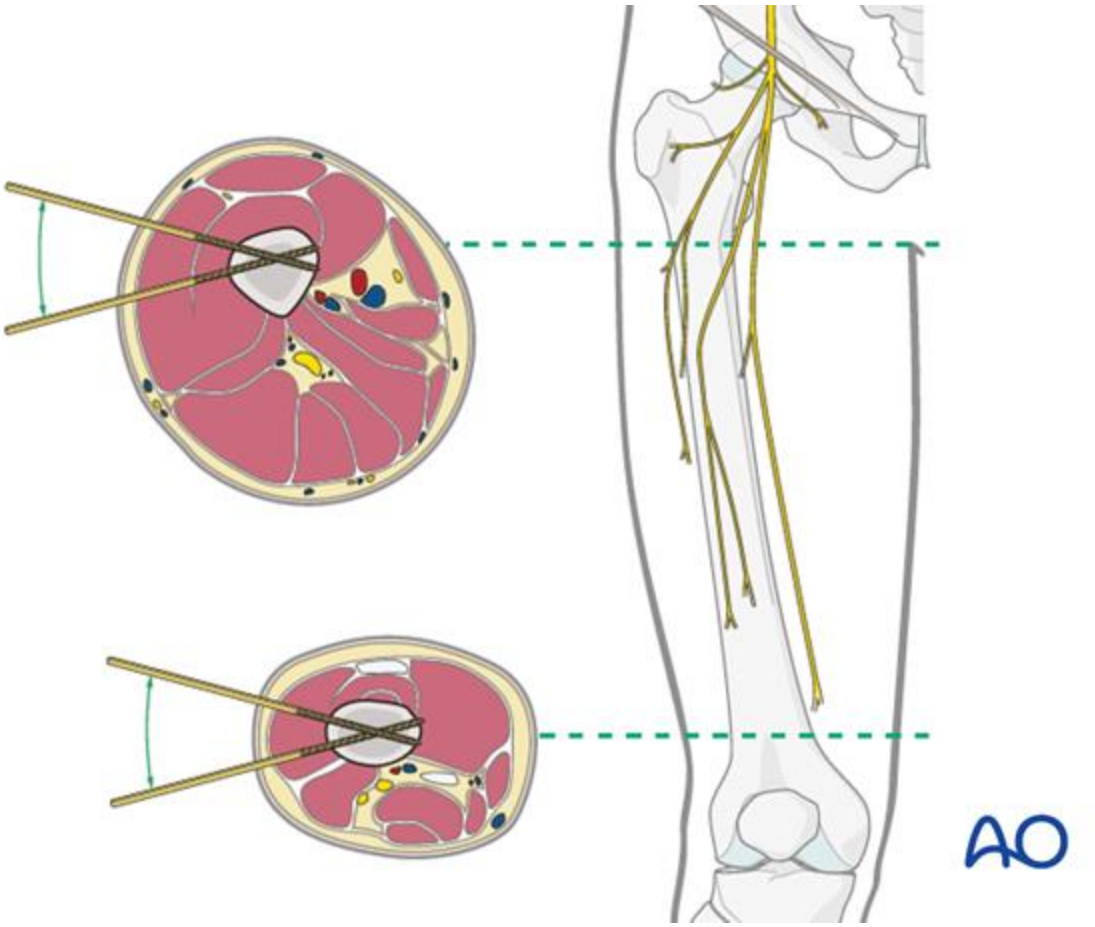
Prior to pin insertion, it is advisable to correct by manual traction any rotational deformity as well as any overlap of the fracture fragments. By maintaining axial traction, it will be possible to optimize pin placement, thereby facilitating the subsequent reduction maneuvers.



Pin placement

For safe pin placement make use of the **safe zones** and be familiar with the anatomy of the femur.

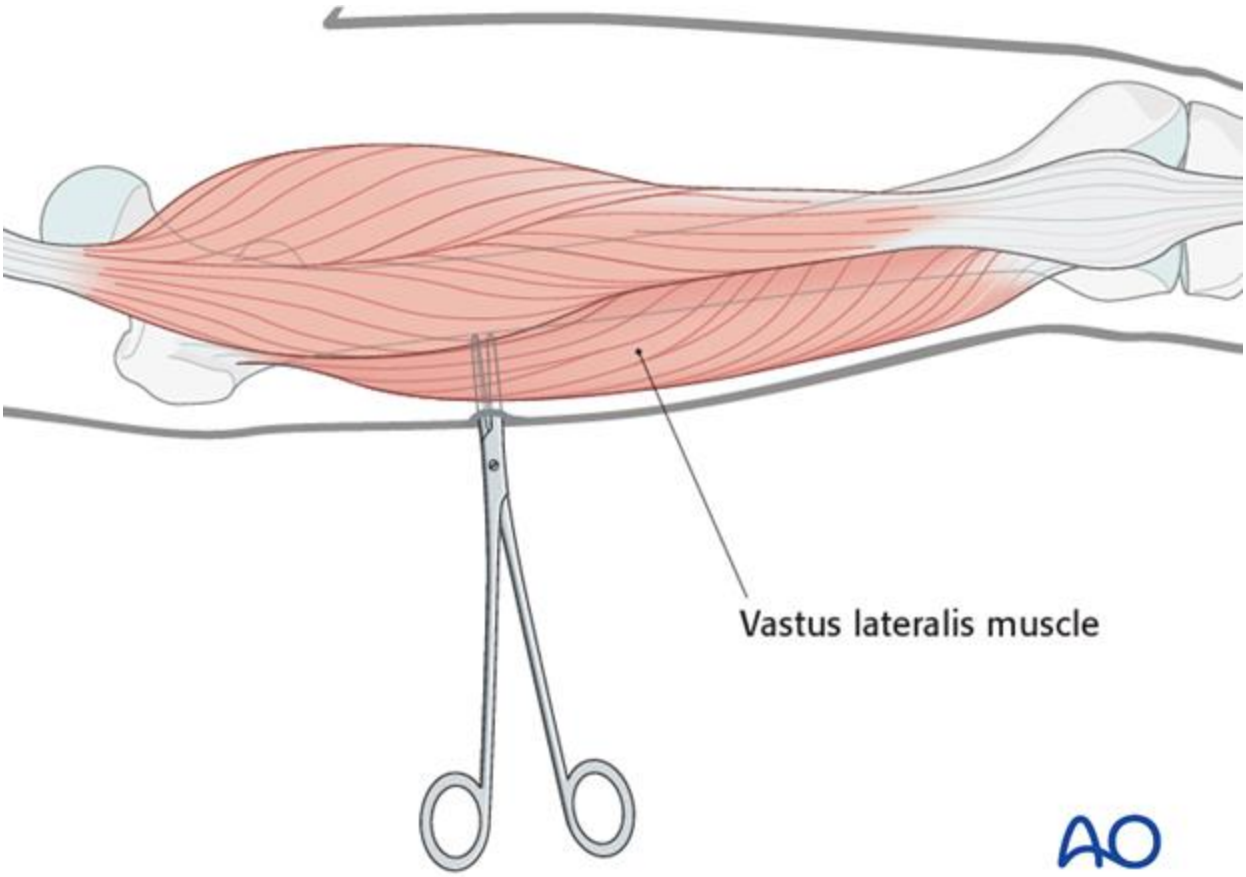
The safe zone for the femur is lateral. In temporary external fixation, the pins should be placed so that they do not interfere with planned later definitive fixation; this may mean placing femoral pins a little anteriorly.



Soft-tissue dissection

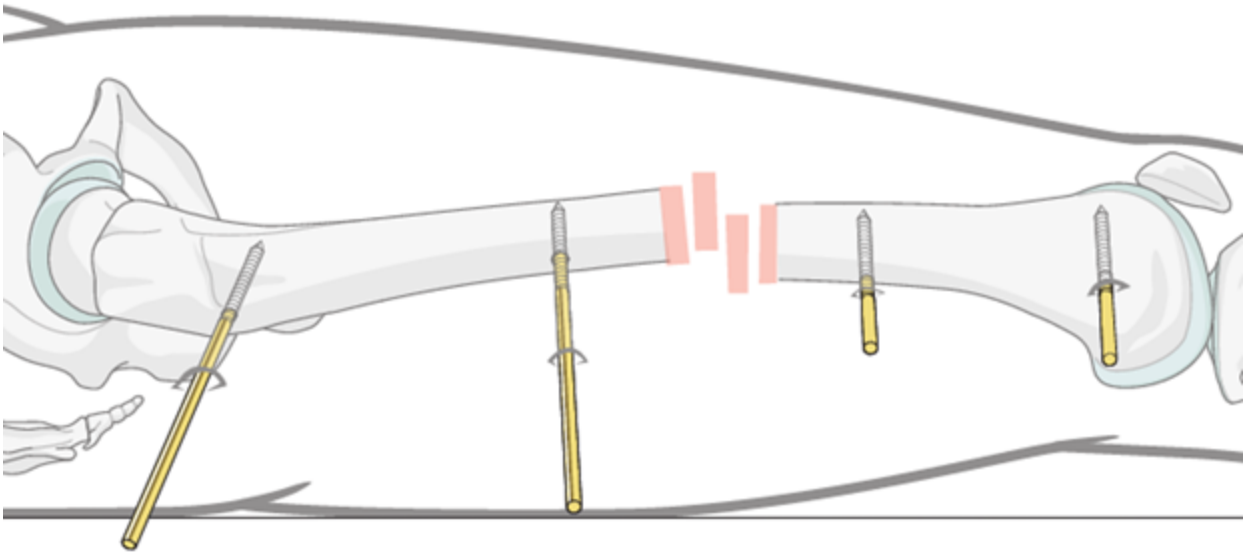
Blunt dissection of the soft tissues and the use of small Langenbeck retractors will minimize muscular damage.

Using a straight clamp, prepare a channel for the insertion of the pin.



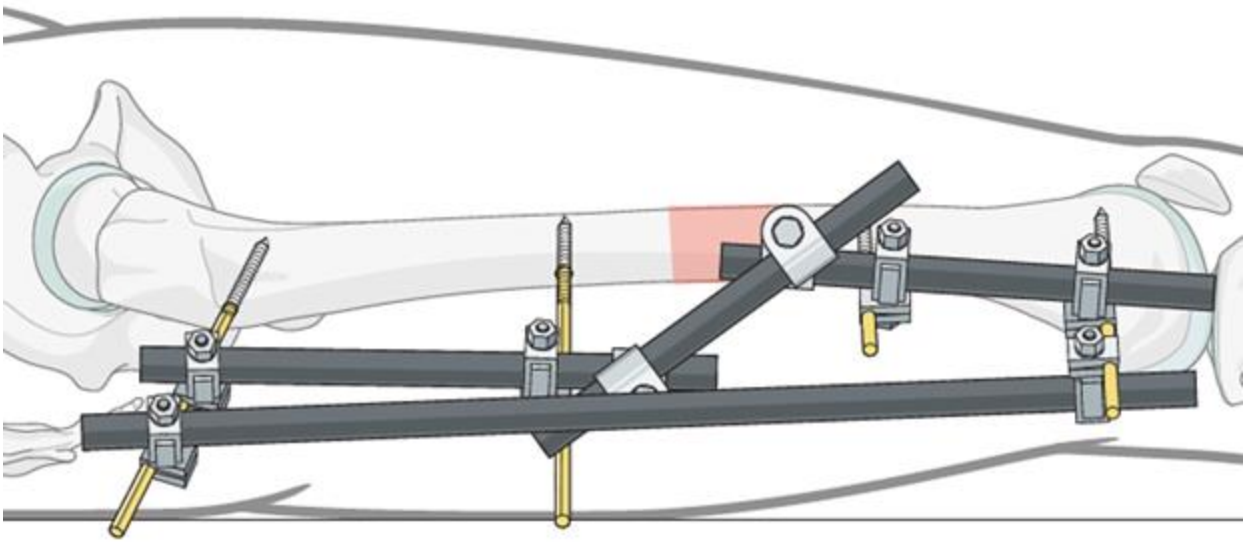
Pin insertion

When applying three pins in each fragment, insert only two pins initially and link with a rod fully loaded with three clamps. After tightening the clamps on the initial two pins, insert the third pin through its relevant clamp. If all three pins are inserted at once, it may prove impossible to link all three to the tube, if they are in slightly different alignments.



5. Frame construction / reduction and fixation (femoral shaft)

To increase frame stability a neutralization rod should be added.



Pearl

In distal shaft fractures or supracondylar fractures fixation can be accomplished a) by non-spanning external fixation with two pins in the condyle or b) by joint-spanning external fixation from femur to tibia as described in the distal femur module.

6. Potential postoperative complications

Loss of reduction

In cases of delayed conversion of the external fixator to a definitive fixation, check x-rays are advisable within the first week and regularly thereafter, to ensure that the quality of reduction has been maintained.

Compartment syndrome

Close monitoring of the femoral muscle compartments should be carried out, especially during the first 48 hours, to ensure that compartment syndrome, requiring decompression by urgent fasciotomy, has not developed.

7. Aftertreatment following temporary external fixation

The patient should be taught appropriate pin-track care.

Whether the external fixation is temporary or definitive must be decided early after its placement. If desired, conversion to a nail or plate should be done within a week or two, before pin sites become infected. Of course, the patient's general condition and local soft tissues must have become suitable to allow conversion of the external fixator to either a nail or plate.

If soft-tissue problems persist and/or the external fixator has been left on for 3 weeks or longer, the following steps need to be taken:

- Remove the external fixator and curette and wash the pin sites.
- Temporarily stabilize the femoral fracture in a Thomas's splint.
- Let pin-tracks heal and then proceed to either nailing or plating.

Thick soft tissues around external fixation pins should be stabilized with compressive dressings or sponges. Otherwise, once bleeding has ceased, dressings can be replaced with daily pin site cleansing and an antibacterial ointment.

In the rare event that the fixator becomes the definitive fixation the aftercare should follow the guidelines as for definitive external fixation, as follow:

Functional treatment

Unless there are other injuries or complications, mobilization may be started on postoperative day 1. Special emphasis should be placed on active knee and hip flexion. Continuous passive motion may be used, but interrupted from time to time for active muscle strengthening exercises.

Weight bearing

Partial weight bearing (touch down, or 10-15 kg) may be performed with crutches or a walker. In transverse fractures weight bearing may be performed more assertively.

Follow-up

Wound healing should be assessed regularly on a short term basis within the first two weeks. Subsequently 6 and 12 week follow-ups are usually undertaken and more as indicated until the fracture has united.
Pin site care should be carried out daily until the frame is removed following fracture healing.