Principles of external fixation

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Review

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Learning outcomes

At the end of this lecture you will be able to:

- Outline indications for external fixation
- List different types of external fixators
- Discuss the modular technique
- Outline the technique considering corresponding instruments, implants, and aftercare

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Indications

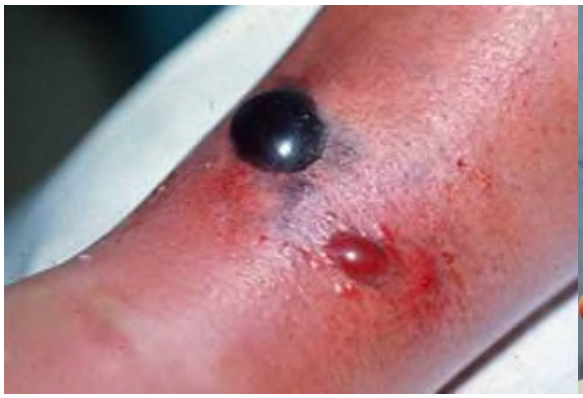
I. Fractures with soft-tissue damage
II. Polytrauma—damage control surgery
III. Skeletal infection
IV. Corrective surgery

The external fixator can be used for many reasons and in many ways.

The two areas in which the fixator is used are traumatology and elective orthopedic surgery. In this presentation, we shall only discuss the use of the external fixator in traumatology.

Indications

I. Fractures with soft-tissue damage



Closed fractures with soft-tissue compromise

Open fractures with soft-tissue wounding

Indications are fractures with severe soft-tissue damage:

- Closed fractures with soft-tissue compromise
- Open fractures with soft-tissue wounding

Indications

II. Polytrauma

Multiple fractures … …often following road traffic accidents

In a polytrauma case the external fixator has to be applied as fast as possible to stabilize the patient and safe his life and limb.

A polytrauma patient is often treated in different stages:

1. Application of (an) external fixator(s).
2. The definitive treatment is done later depending on the condition of patient.

Indications

III. Infection

1. Postoperative infection 2. Debridement

When the wound is infected,

1. Debridement will remove all dead and infected tissue—including bone.

Indications

III. Infection

3. External fixation

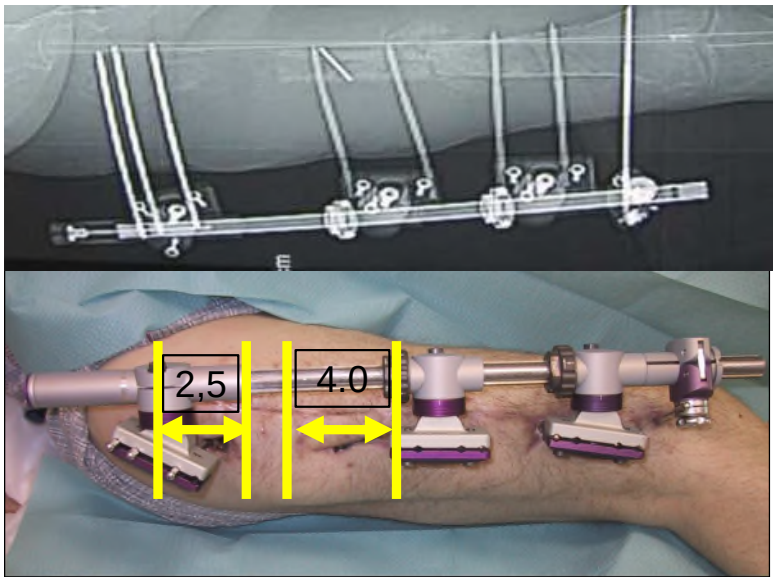
When the wound is infected,

1. Debridement will remove all dead and infected tissue—including bone.
2. The fracture will then be stabilized temporarily by external fixation.
3. Final osteosynthesis is done later, once the infection is cured.

Indications

IV. Corrective surgery

Limb lengthening:
Segment transportation with callus distraction



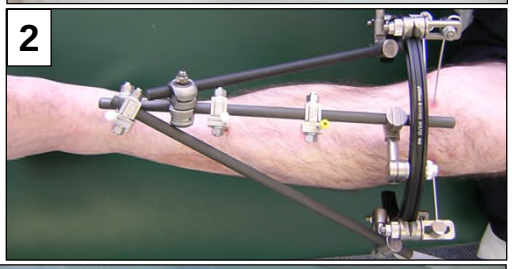
Limb lengthening with callus distraction.

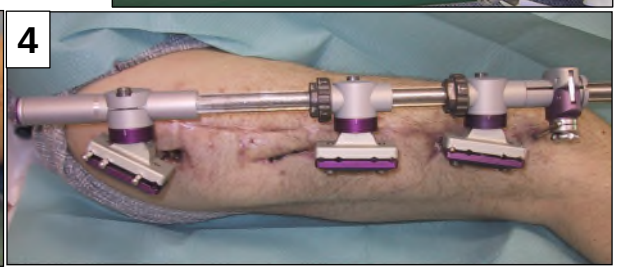
6.5 cm can be achieved to restore the full length of the limb (2.5 plus 4.0 cm).

Types of external fixators

Different systems:

1. Modular
2. Hybrid
3. Ring
4. Monotube





This presentation will mainly outline the modular technique.

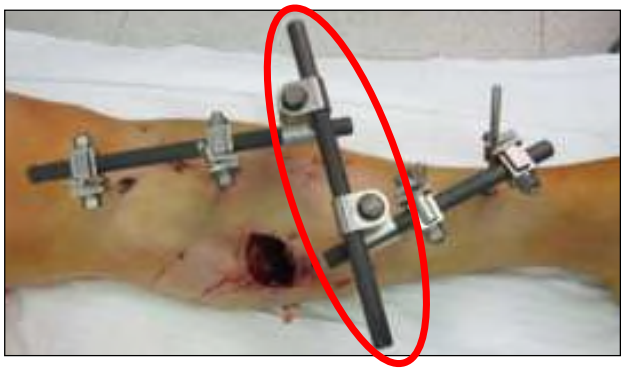
The ring, hybrid, and monotube fixators are briefly explained in the next slides.

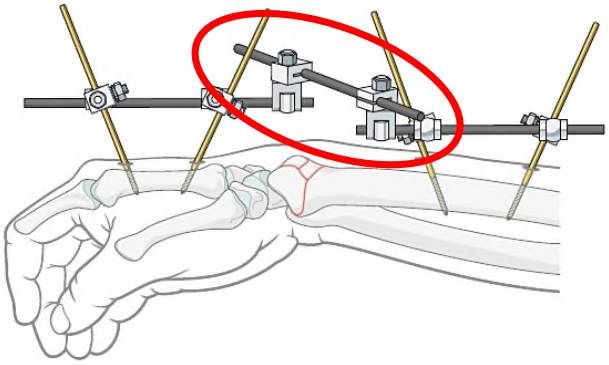
1. Modular system

- Any limb

Reduction and fixation achieved with a third rod

- Any joint



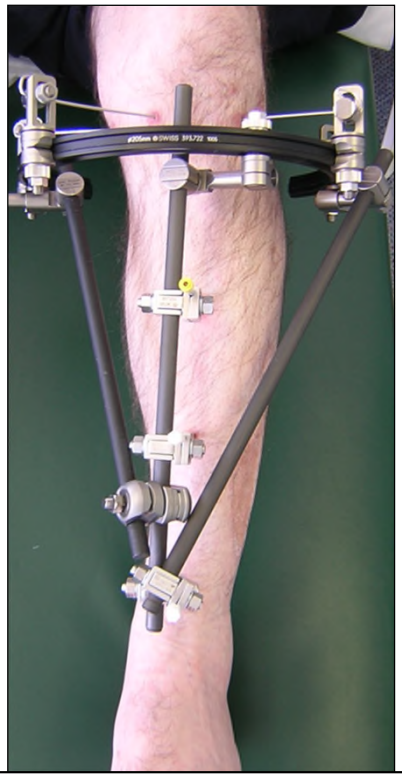


The modular system can be applied anywhere; for an individual bone fracture or for joint bridging fractures.

First, two pins are inserted in each segment of the fractured bone. Second, a rod will be fixed in parallel to the bone segment using clamps. Third, this is repeated for the other segment. Finally a third rod will be loosely fixed (once again with clamps) from rod to rod. Once the reduction is performed the clamps of the third rod will be tightened so that the fracture is fixed.

2. Hybrid system

- Combination of:
  - Half-ring or ring
  - Unilateral system
- Used to fix periarticular fractures
- Secondary procedures
  (eg, septic cases):
  - Alone
  - In combination with other implants



Hybrid ring fixators refer to combinations of two types of fixator, such as a half-ring fixator plus unilateral external fixation systems.

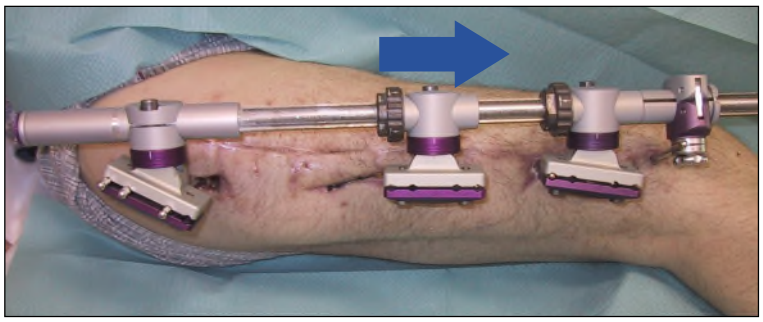
3. Ring system

Corrective procedures:

- Lengthening of shortened limbs
- Correction of (rotational) deformities
- Segmental bone transport

To achieve complex corrections in several planes, or just fracture stabilization.

4. Monotube system



Corrective procedures:

- Lengthening of shortened limbs
- Segmental bone transportation

AO

Corrective procedures can be performed in order to

- Lengthen of shorten limbs
- Correction rotational deformities
- Perform segmental bone transport (in this case as mentioned before 6 cm)

Basic implants for tube/rod external fixators

1. Schanz screws
2. Steinmann pins
3. Clamps
4. Rods and tubes

1. Schanz screws

- Different lengths
- Different diameters
- Self-tapping (standard)
- Self-drilling

Self-tapping

Self-drilling

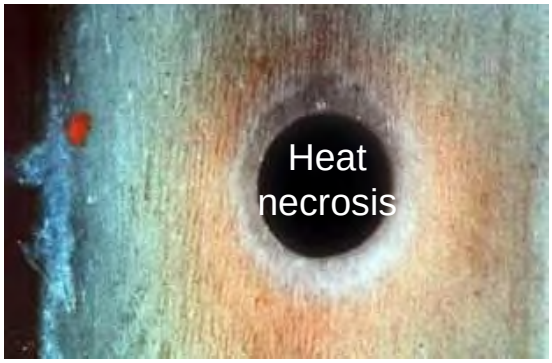
The chosen diameter of the Schanz screws depends on the system that is selected for a particular fracture and on the bone size.

For example, for a tibial fracture, Schanz screws with a diameter of 5mm are used (2.5mm Kirschner wires or threaded pins are used for the small fixator).

Threads can be coated with hydroxyapatite to avoid loosening of Schanz screws. This is a mineral related to apatite which is the main inorganic constituent of tooth enamel and bone.

Care when inserting screws

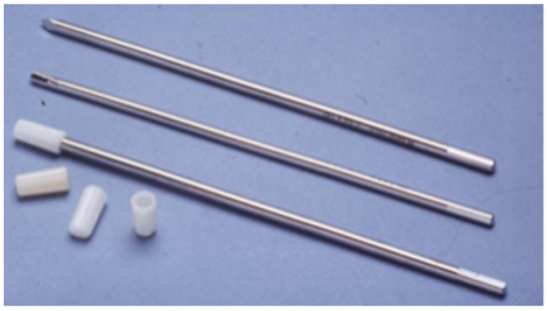
- Always irrigate during drilling/insertion in cortical bone
  - To reduce thermal necrosis of bone



When predrilling for a Schanz screws (drill bit 3.5mm), or inserting a self-drilling Schanz screw, continuous irrigation is required in order to decrease heat development. The heat produced can lead to necrosis of the bone (see picture on the right).

2. Steinmann pins

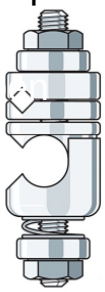
- Unthreaded and threaded
- With a sharp tip
- Through body of bone:
  - Calcaneus
  - Tibial head, etc.



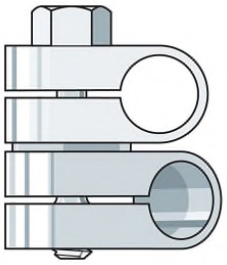
3. Clamps

- Combining pin-to-rod
  - Closed
  - Open
- Combining rod-to-rod
  - Only rod-to-rod
  - Rod-to-pin which can be combined with pin fixation

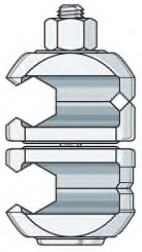
Open



Rod-rod



Rod(s)-Pin(s)

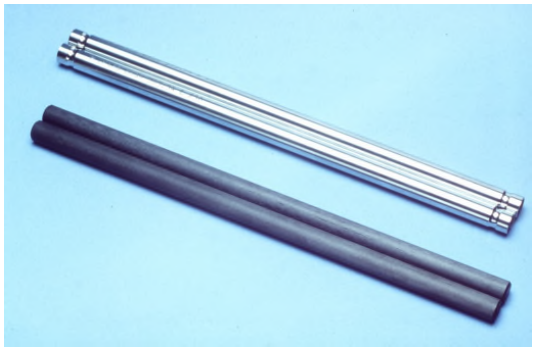


There are several types of clamps to connect the rods to the Schanz screws. The open clamps allow easier fixation on the rods (by snapping them on) than the adjustable (or closed) clamps.

Rod-to-rod clamps allow fixation of one rod to another rod. Over time several types of rod-to-rod clamps have been produced.

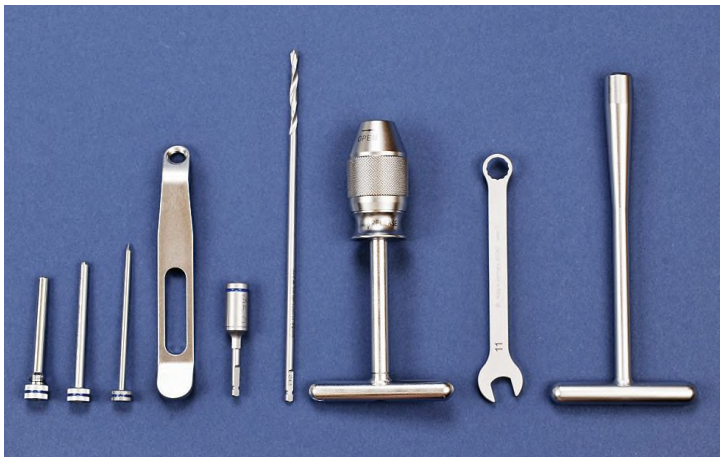
4. Rods to link pins with clamps

- Stainless steel
- Carbon fiber



Rods come in steel, or carbon fiber, in different lengths and diameters, to stabilize the frame by linking pins, via clamps.

The advantages of carbon fiber rods are that they are radiolucent and are available in curved versions. They are, however, much more expensive.



- Protection sleeves with handle
- Power adapter (optional) for Schanz screws
- Drill bit
- Universal chuck with T-handle
- Combination wrench
  - Assists final tightening of all nuts
- Socket wrench

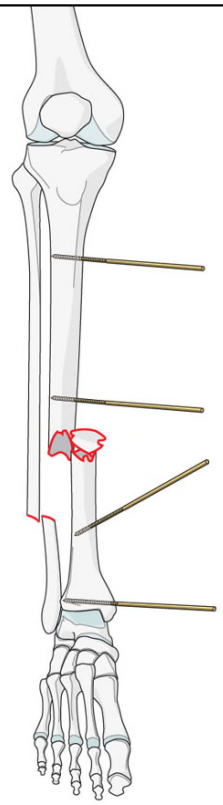
The drill bits are inserted with a power tool, using cold irrigation.

The protection sleeves can be used for 5.0mm and 6.0mm Schanz screws.

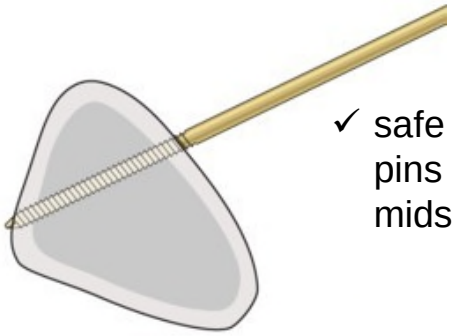
Power adapters for easy attachment are also available in different sizes matching the Schanz screw.

The universal chuck T-handle is used for fine adjustment of insertion respecting the correct depth.

Surgical modular technique



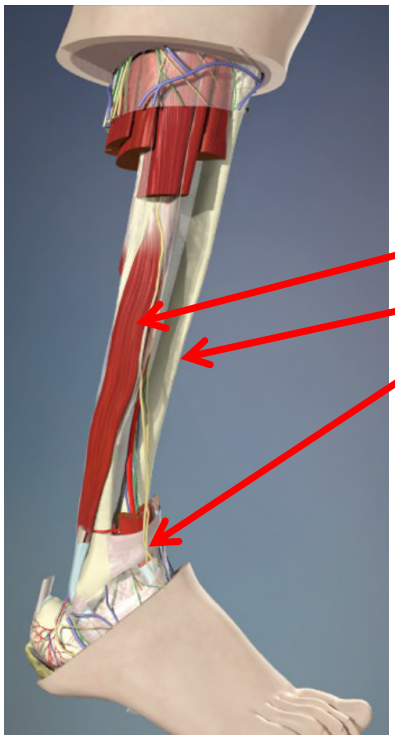
1. Pin insertion



✓ safe position of pins
midshaft tibia

Insert 2 pins on each side of the fracture in the safe zones.
Proximal pins should be inserted from anterior to posterior.
Distal pins should come from medial to lateral.

Safe pin insertion in tibia



- Not through muscles on lateral side
- Not on tibial crest
- Not through distal tendons

Lateral view

Picture: Primal pictures

Schanz screws should ideally be inserted from anteromedially.

Penetration of fibula, ligaments and nerves must be avoided.

Anteromedial view

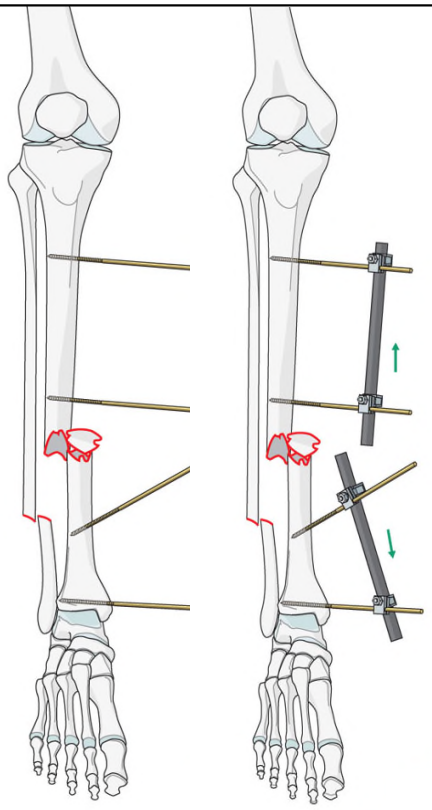
Safe pin insertion in tibia

- Not through muscles on lateral side
- Not on tibial crest
- Not through distal tendons

But

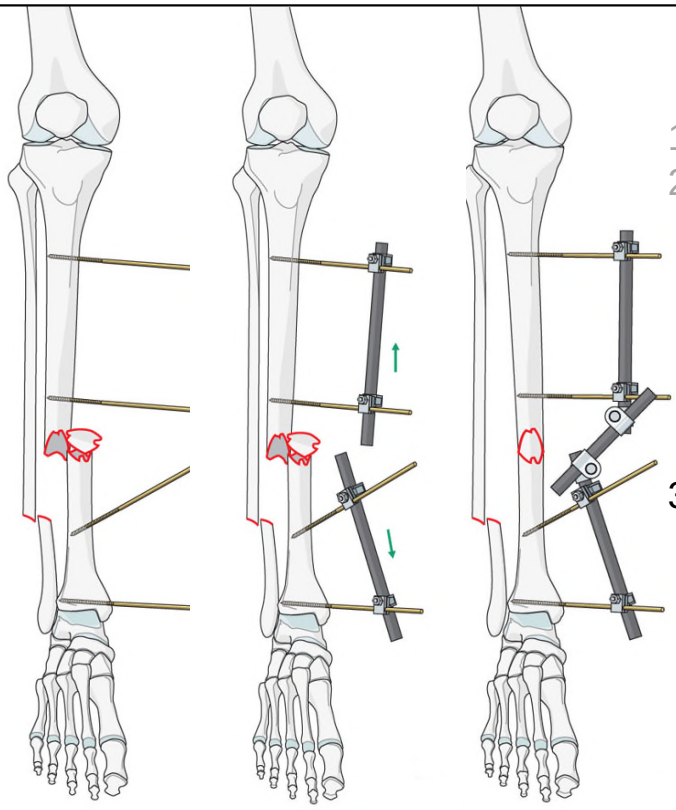
- From the anteromedial side

Picture: Primal pictures



1. Pin insertion
2. Fix rods/tubes to pins
   - Create a “partial” frame for each main fragment
   - Tighten all nuts very well

With help of clamps, a rod is mounted on each side of the fracture. The rods will be used in a later stage as “handles” when the reduction is performed.



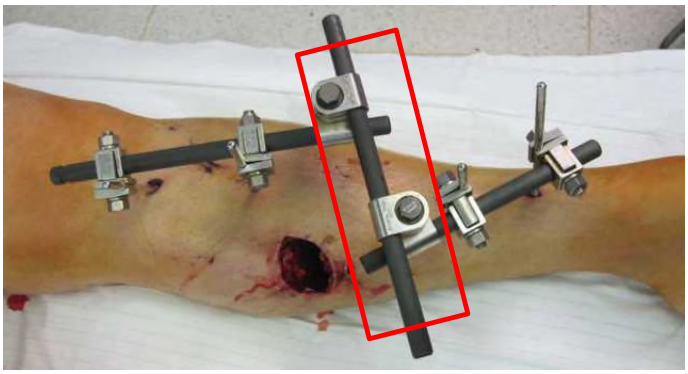
1. Pin insertion
2. Fix rods/tubes to pins
   - Create a “partial” frame for each main fragment
   - Tighten all nuts very tightly
3. Apply third rod using two rod-to-rod clamps yet loosely
   - Reduce fracture
   - Tighten nuts

Mount the third short rod, using two tube-to-tube clamps: leave the two tube-to-tube clamps loose.

The fracture is then reduced and finally fixed by tightening the nuts.

Reasons for using the modular technique

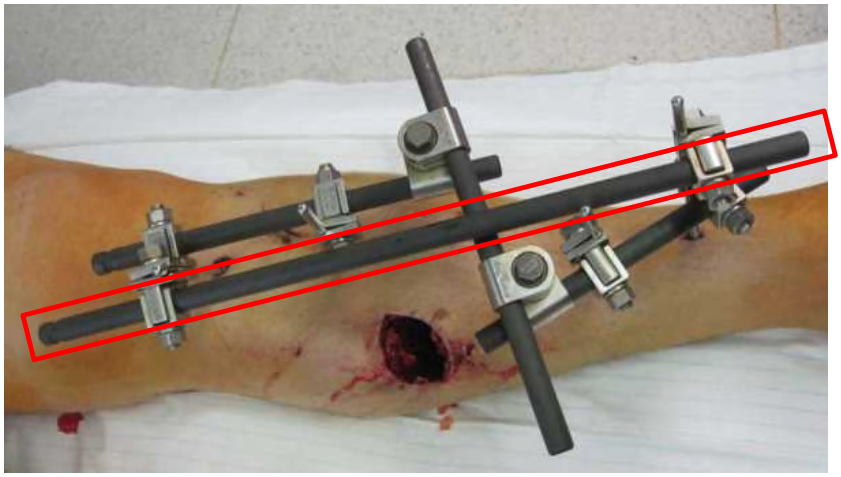
- Gentle fracture reduction is performed in a second step
- Only if one rod was used, reduction would have been performed first (more traumatizing)



The modular technique using three rods allows the first two rods to be attached, one to each fragment. When the reduction has been achieved, the third rod locks the first two in that position.

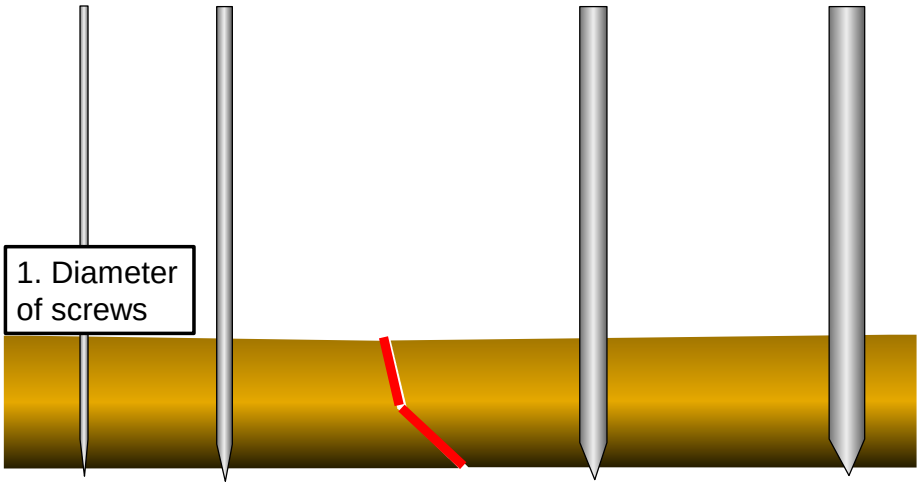
If more stability/neutralization of forces is required

- Add an additional rod



The frame can be strengthened by adding another rod.

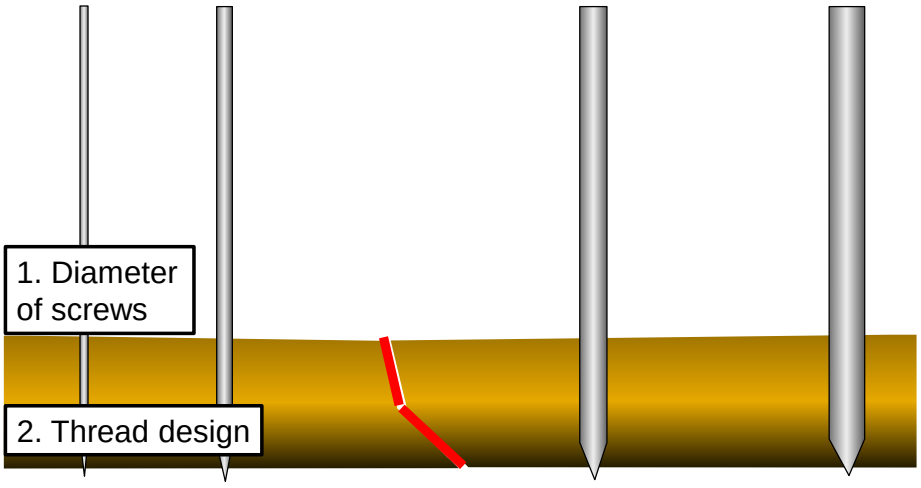
Factors influencing the stiffness of a frame



There are six factors influencing stiffness of a frame.

1. The stiffness of the frame increases with the thickness of a screw.

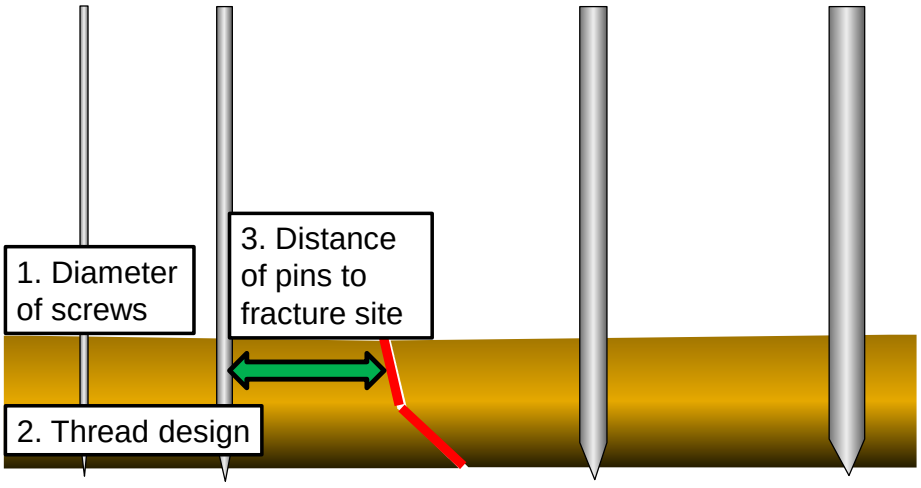
Factors influencing the stiffness of a frame



There are six factors influencing stiffness of a frame.

1. The stiffness of the frame increases with the thickness of a screw.
2. The thread design will define the holding strength in the bone.

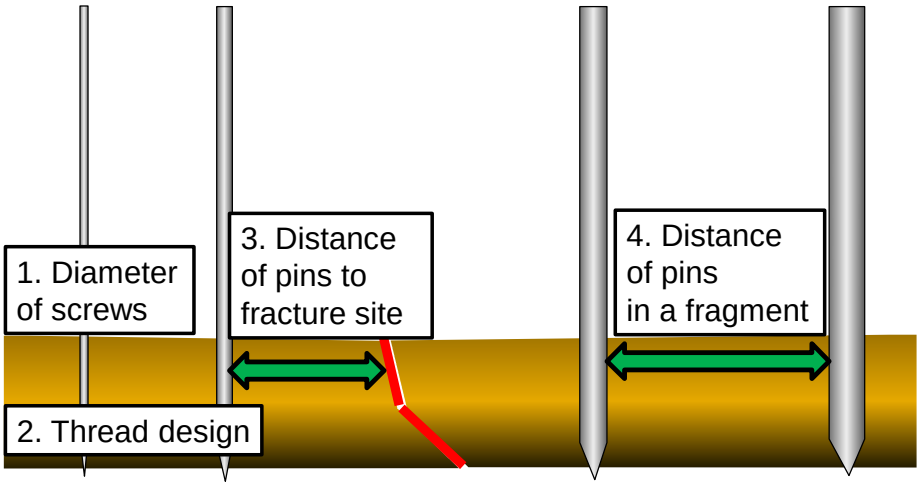
Factors influencing the stiffness of a frame



There are six factors influencing stiffness of a frame.

1. The stiffness of the frame increases with the thickness of a screw.
2. The thread design will define the holding strength in the bone.
3. It is better to insert a pin as close as possible to the fracture site.

Factors influencing the stiffness of a frame



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1. The stiffness of the frame increases with the thickness of a screw.
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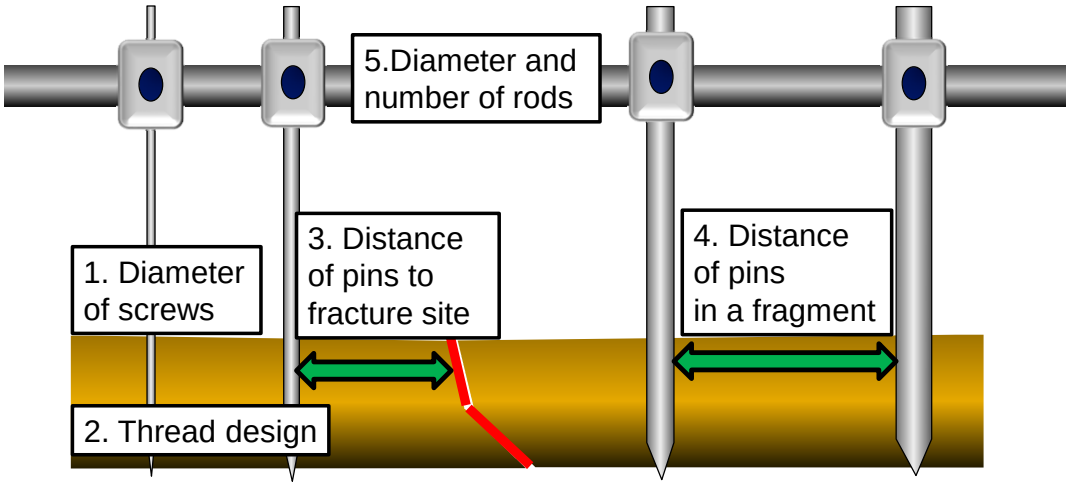
4. Through larger distances between the pins in a fragment, the holding strength increases.

Factors influencing the stiffness of a frame



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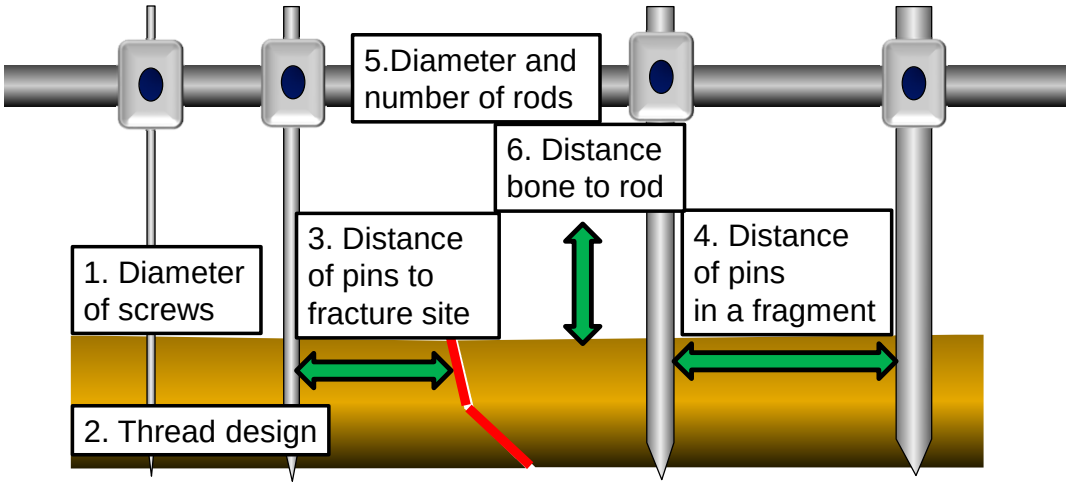
1. The stiffness of the frame increases with the thickness of a screw.
2. The thread design will define the holding strength in the bone.
3. It is better to insert a pin as close as possible to the fracture site.
4. Through larger distances between the pins in a fragment, the holding strength increases.
5. Also, a second rod will additionally increase the stiffness.

Factors influencing the stiffness of a frame

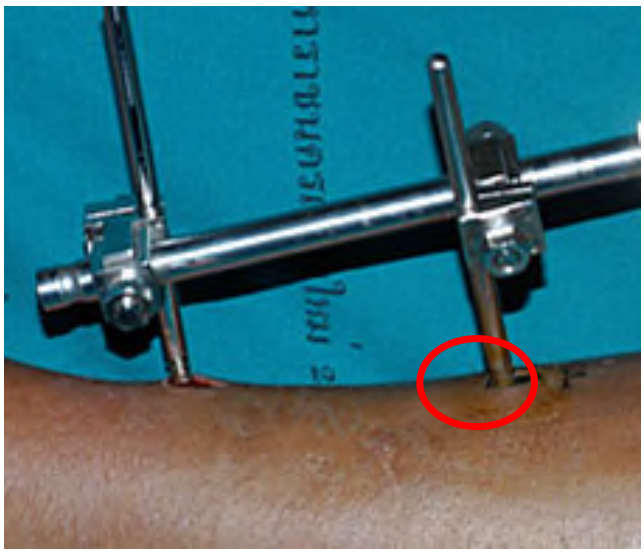


There are six factors influencing stiffness of a frame.

1. The stiffness of the frame increases with the thickness of a screw.
2. The thread design will define the holding strength in the bone.
3. It is better to insert a pin as close as possible to the fracture site.
4. Through larger distances between the pins in a fragment, the holding strength increases.
5. Also, a second rod will additionally increase the stiffness.
6. A rod placed close to the bone will result in a stiffer frame construct than a rod placed far away from the bone.

Postoperative care to prevent pin infection

- Pins should not irritate the skin after insertion



Inserted pins may not irritate the skin.

Free placement important.

No mechanical stress should be applied on skin in order to prevent infection.

Postoperative care to prevent pin infection

Removal of crusts

The goal is to remove any debris, such as crusts or exudates. There is no evidence for a best-practice option.

The following slides show the recommended practice (from a major trauma center in Germany).

Postoperative care to prevent pin infection

Removal of crusts

Saline or disinfectant solution

Cleaning can be done with saline or a disinfectant solution.

Postoperative care to prevent pin infection

Removal of crusts

Saline or disinfectant solution

Cleaning

A cotton swab can be used.

Long-term care to prevent pin infection

In cases in which definitive fracture treatment is foreseen using an external fixator, the patient is trained to clean the limb and the external fixator.

The patient can shower or can even go for a swim in the ocean.

In case of any color change of the skin or appearance of exudates around the pin, they are instructed to report to the surgeon as soon as possible.

Questions

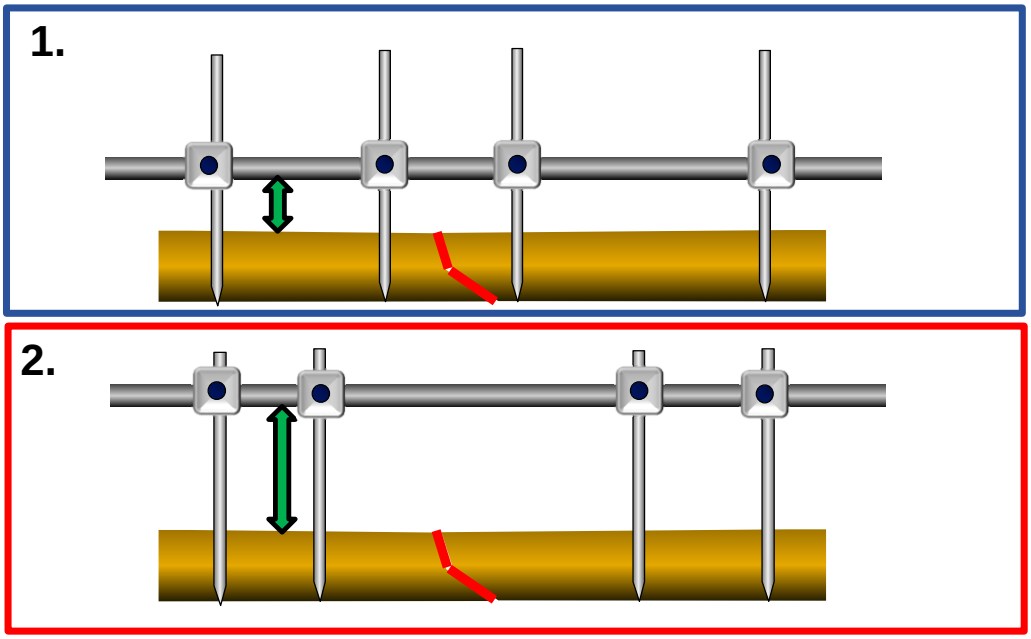
Optional:

Insert questions to check learning.

The first question is an open question. Ask one of the participants.

For the second and third question, the use of ARS or colored cards is advised.

Which frame is more stable/stiff?



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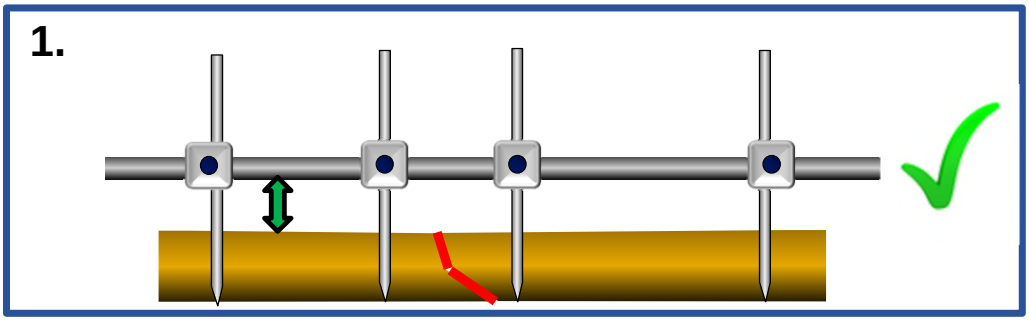


A rod placed close to the bone will result in a stiffer frame construct.

Also a second rod will additionally increase the stiffness.

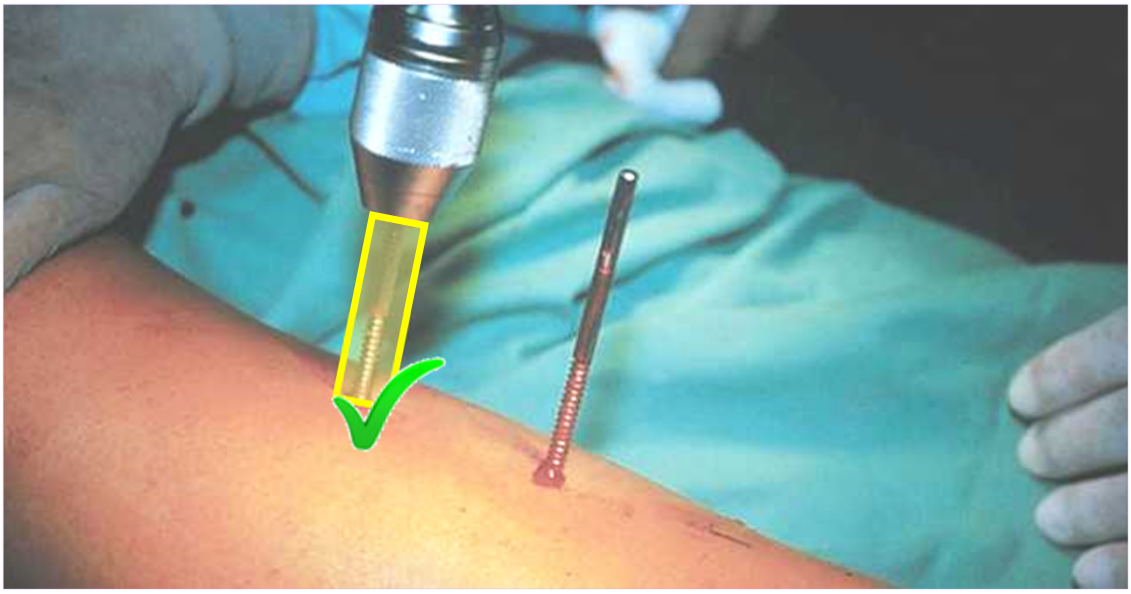
Any external fixation frame will provide relative stability and secondary bone healing will occur.

What is missing?

Optional:

Insert questions to check learning.

What is missing?



Optional:

Insert questions to check learning.

Which size of drill bit is required for inserting a 5 mm standard Schanz screw?

1. A 4.5 mm drill bit

2. A 3.5 mm drill bit

3. A 3.2 mm drill bit

Optional:

Insert questions to check learning.

Which size of drill bit is required for inserting a 5 mm standard Schanz screw?

1. A 4.5 mm drill bit
2. A 3.5 mm drill bit
3. A 3.2 mm drill bit

Optional:

Insert questions to check learning.

What is the advantage of the modular technique?

1. It allows a gentle reduction of the fracture

2. It allows best pin care after surgery

3. It provides absolute stability

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Insert questions to check learning.

Summary

You will now be able to:

- Outline indications for external fixation
- List different types of external fixators
- Discuss the modular technique
- Outline the technique with corresponding instruments, implants, and aftercare

You will now be able to

- Outline indications for use of external fixators
- List different types of external fixators
- Discuss criteria for stability of frame
- Outline technique with corresponding instruments, implants and aftercare