

Principles of intramedullary nailing

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Learning outcomes

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

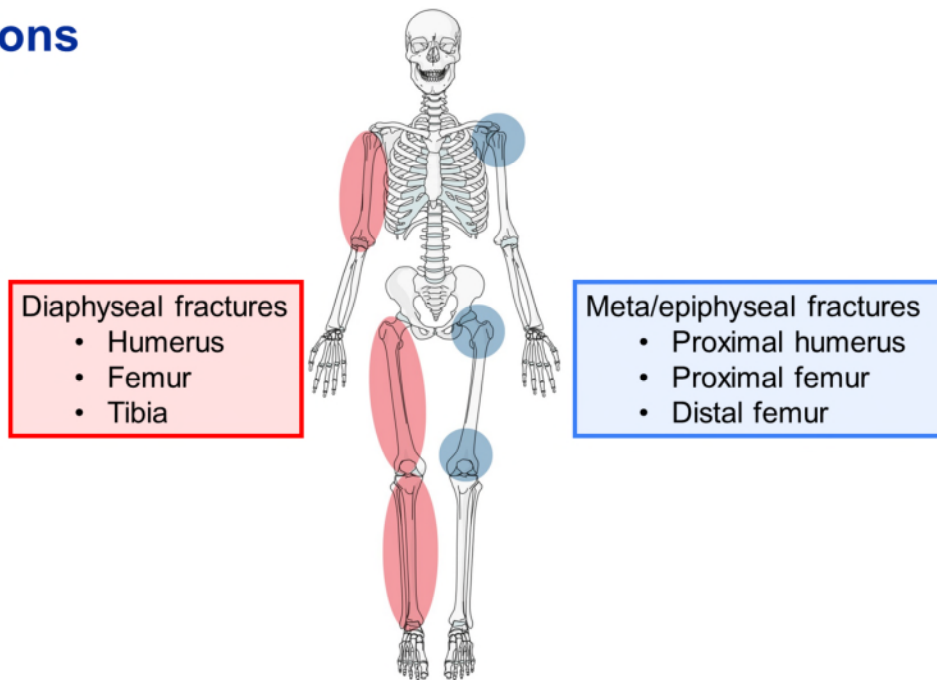
- List indications for an osteosynthesis with an intramedullary nail
- Explain how an intramedullary nail works
- Discuss the design of different nails
- Describe the surgical technique

AO

At the end of this lecture you will be able to

- List indications for an osteosynthesis with an intra medullary nail
- Explain how an intramedullary nail works
- Discuss the design of different nails
- Describe the surgical technique

Indications



AO

Indications for osteosynthesis with intramedullary nail are

1. Diaphyseal fractures:

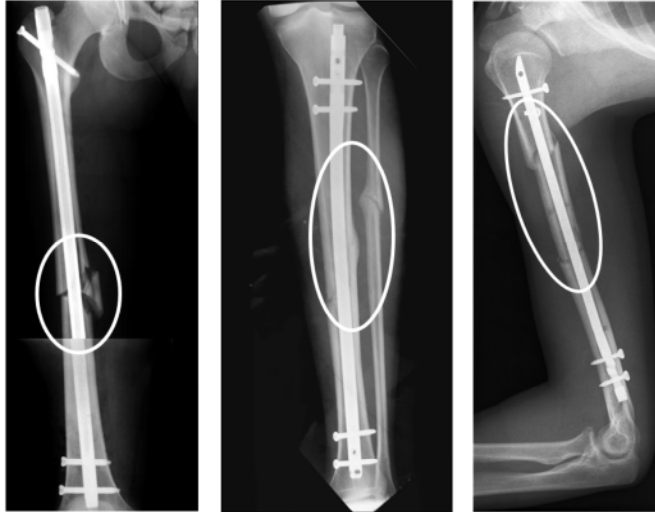
1. Humerus
2. Femur
3. Tibia

2. Meta/epiphyseal fractures:

1. Proximal humerus
2. Proximal femur
3. Distal tibia

Indications

- Fractures of long bones



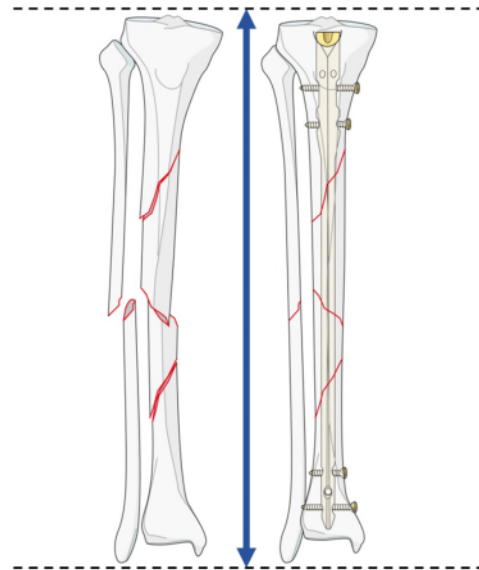
AO

Intramedullary nails are mainly used for fractures of:

- Femur (proximal, distal and shaft)
- Tibia (shaft)
- Humerus (shaft)

Objectives of treatment with a nail

- Restoration of **length** of limb

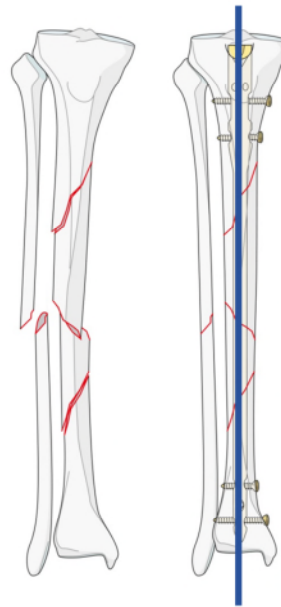


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An intramedullary nail acts as a splint. It's function is to restore the length of limb, ...

Objectives of treatment with a nail

- Restoration of **length** of limb
- Restoration of **load axis**

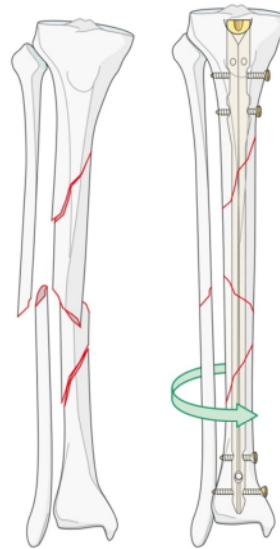
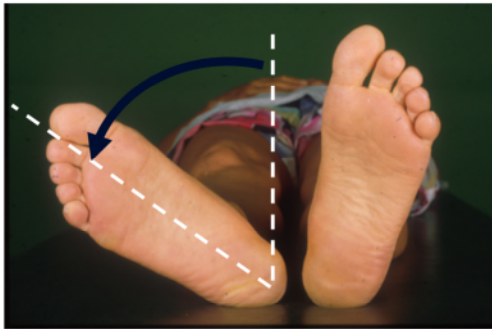


AO

...to restore the axis, ...

Objectives of treatment with a nail

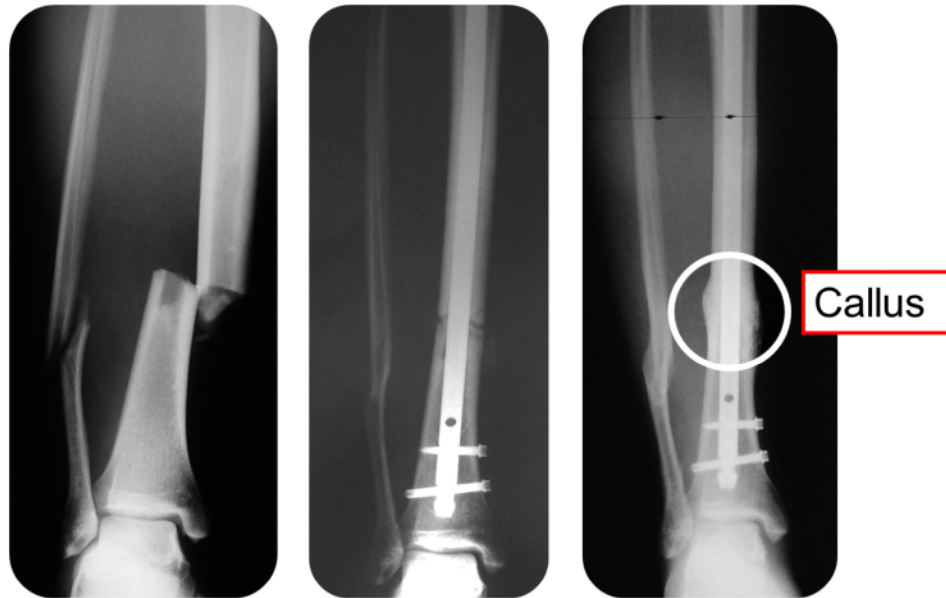
- Restoration of **length** of limb
- Restoration of **axis** of limb
- Restoration of **rotation** of limb



AO

...and to avoid any malrotation.

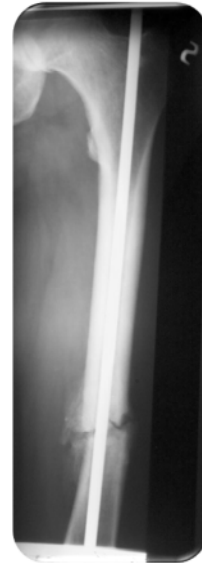
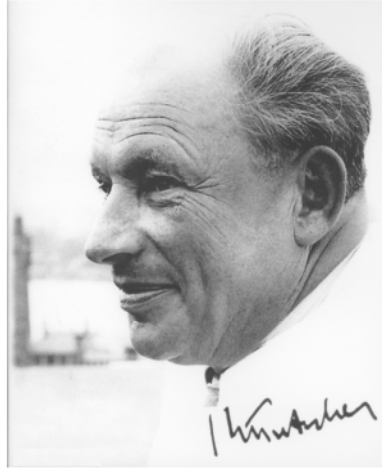
Indirect bone healing—relative stability



Fixation with an intramedullary nail allows (controlled) movement at the fracture site and provides relative stability.

Callus will be formed. This is called indirect bone healing, or occasionally secondary healing.

Gerhard Küntscher (1900–1972)



- No interlocking of his original nails

AO

Static and dynamic interlocking of nails

- What does it mean?

AO

In order to solve the rotational problems interlocking options were created.

Static interlocking



- Proximal and distal:
 - With two or more bolts
 - Used in severe fractures with rotational and/or longitudinal instability
- Reduces collapse in fracture zone



AO

Static interlocking is used in severe fractures.

It reduces compression in the fracture zone. Normally two or more bolts, depending on the type of fracture are inserted proximally and distally.

Dynamic interlocking



- Proximal and distal
 - With one bolt through longitudinal elliptical slots
 - Used in simple fractures
- Allows compression across fracture zone
- Still controls rotational instability



AO

In simple shaft fractures
dynamic interlocking is used.

It increases compression in the fracture zone and encourages callus formation. One bolt only is used proximally and one distally.

Dynamic interlocking



- Weight bearing encourages interfragmentary compression



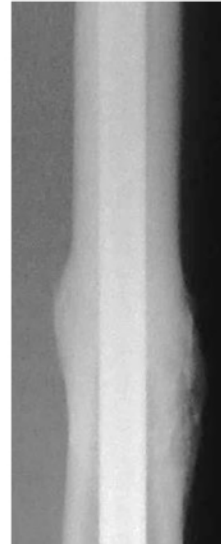
AO

Weight bearing will allow the proximal bolt to move in the oval nail slot and encourages interfragmentary compression (bone healing with callus).

Dynamic interlocking



- Weight bearing encourages interfragmentary compression
- Callus formation in fracture zone



AO

Weight bearing will allow the proximal bolt to move in the oval nail slot and encourages interfragmentary compression (bone healing with callus).

To ream or not to ream?



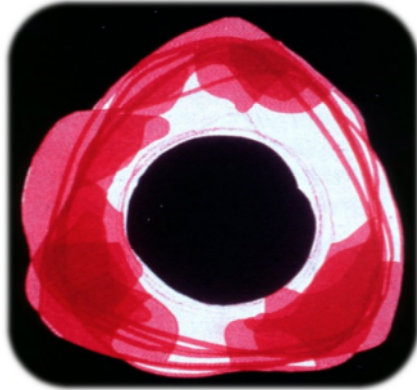
- In the reamed technique, intramedullary blood supply is compromised.

AO

To ream or not to ream?

This is a continuing discussion worldwide. There are convictions for and against reaming. The damage of reaming is based on evidence in AO studies. However the timing of healing may not be influenced.

To ream or not to ream?



- Blood supply in **reamed** technique



- Blood supply in **unreamed** technique

Klein et al (*Arch Orthop Trauma Surg.* 1990;109: 314–316)

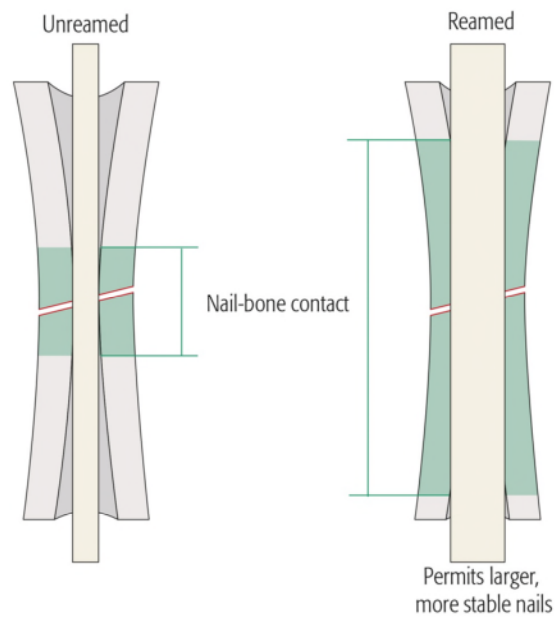
AO

The images show the difference of blood supply in reamed and unreamed applied techniques. The blood supply in unreamed techniques is less compromised.

References:

Klein MP, Rahn BA, Frigg R, et al. Reaming versus non-reaming in medullary nailing: interference with cortical circulation of the canine tibia. *Arch Orthop Trauma Surg.* 1990;109(6):314–316.

Why reaming?



If we compare the nail diameter with the nail-bone contact area, the reamed nail will have a much larger contact area, which results in a more stable fixation.

The larger diameter nail is also less deformable.

Reaming vs nonreaming

	Reaming	Nonreaming
+	<ul style="list-style-type: none"> • Allows insertion of larger diameter nail • High union rates • Shorter healing process 	<ul style="list-style-type: none"> • Shorter procedure • Less damage to blood supply
-	<ul style="list-style-type: none"> • Endosteal blood supply is damaged • High pressure within IM canal 	<ul style="list-style-type: none"> • Lower union rates • Longer healing process • More implant failures

Reaming:

- Is preferable
- Respect contraindications

Brumback et al (*J Am Acad Orthop Surg.* 2000;8:83–90)

AO

The higher pressure within the intramedullary canal of the bone forces debris into the venous circulation. This is believed to increase the systemic inflammatory response implicated in the pathogenesis of acute respiratory distress syndrome (ARDS) and multiple organ failure (MOF). The outcome of this, however, is not yet fully understood.

Reaming should be kept as short as possible, or even avoided, in severely injured patients, or patients with a significant lung injury.

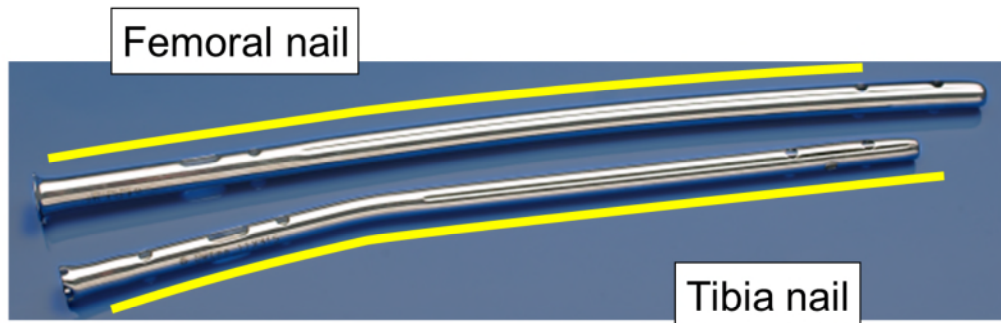
Reference:

Brumback RJ, Virkus WW. Intramedullary nailing of the femur: reamed versus nonreamed. *J Am Acad Orthop Surg.* 2000 Mar-Apr;8(2):83–90.

Type of nails

Design/form:

- Depends on anatomical region



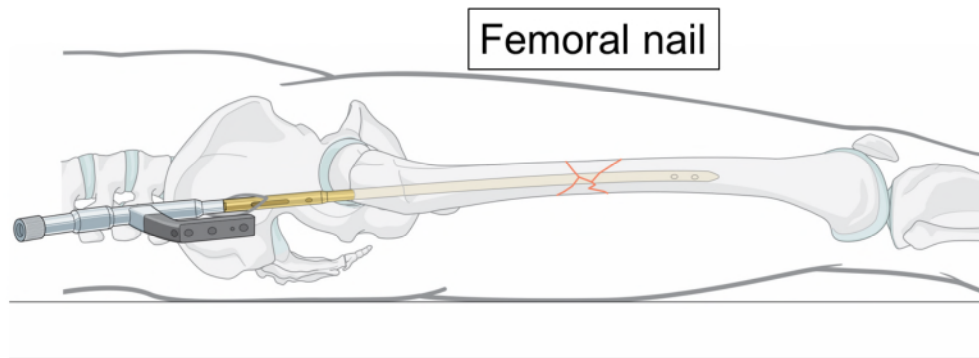
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The design of the nail will depend on the region for which it is used. Nails for femoral shafts are bend differently than nails for tibia or humerus. Also length and diameter will be different.

Type of nails

Design/form:

- Depends on anatomical region



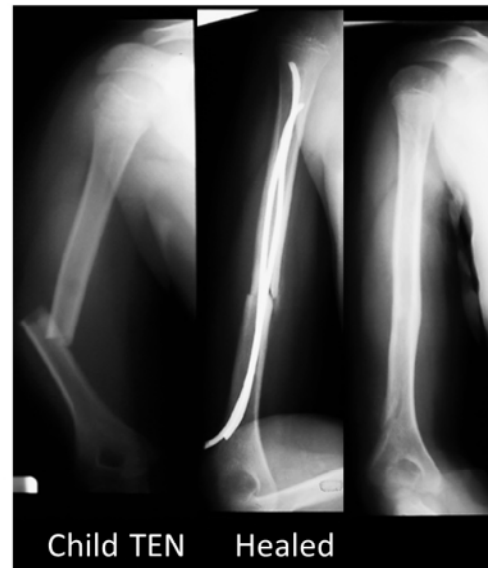
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The design of the nail depends on the region for which it is used. Nails for femoral shafts are bent differently from nails for tibia, or humerus. Also lengths and diameters will be different.

Type of nails: *Example*

Titanium elastic nails
(TENs):

- For different anatomical regions
- Mainly in children



AO

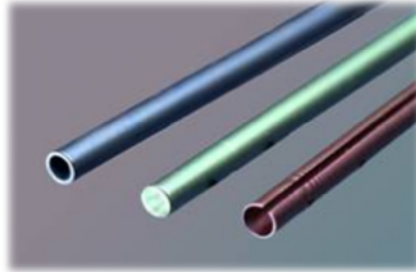
These are solid thin nails used often in children.

Courtesy: Dr. Teddy Slongo, Bern

Type of nails

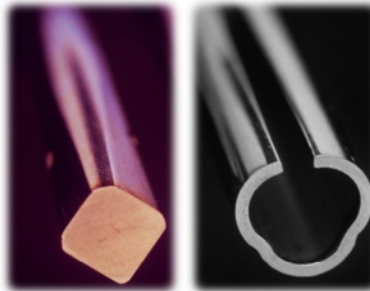
Design:

- Cannulated
- Solid
- Hollow and slotted



Material

- Titanium
- Stainless steel

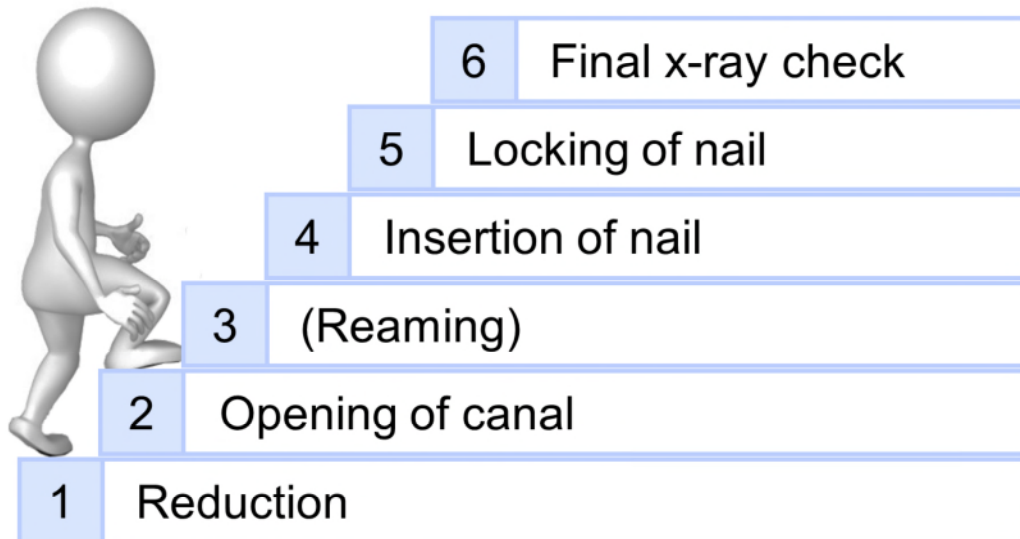


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The design of the nail plays an important role in its mechanical strength. Solid nails will be stronger than hollow (slotted) nails. For both the diameter, and the thickness of the wall of the hollow nail, play an important factor.

Besides diameter and thickness the material of which the nail is made is also important: Steel nails are stronger, but have a greater rigidity than titanium nails of the same dimension.

Surgical technique step-by-step



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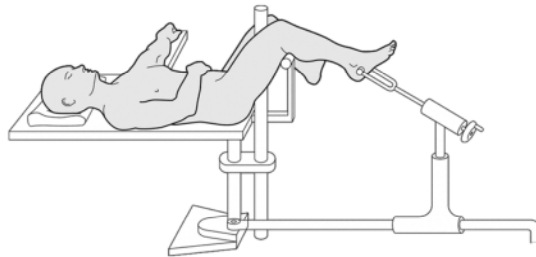
The surgical techniques consists of a maximum of 6 steps.

1. The fracture is reduced. This can be done before or during the operation.
2. The intramedullary canal is opened.
3. If required the intra medullary canal is reamed.
4. The nail inserted.
5. The nail locked if required (proximally and distally).
6. Final -ay control

1. Reduction

Indirect—closed:

- Before operation
 - Traction table



AO

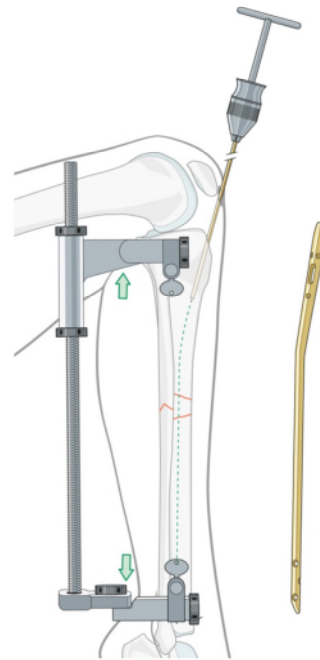
The fracture will be reduced closed, thus indirectly.

In some cases a fracture table may be used: e.g., fracture of the proximal femur, tibia shaft (less common), etc.

1. Reduction

Indirect—closed:

- Before operation
 - Traction table
- During operation
 - Large distractor

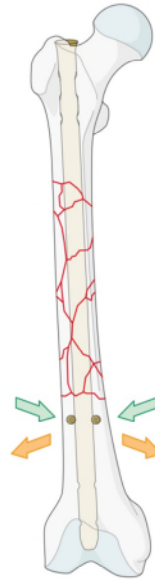


Here an external large distractor helps to achieve the reduction process in a gentle and controlled process.

1. Reduction

Indirect—closed:

- Before operation
 - Traction table
- During operation
 - Large distractor
 - Poller screws



AO

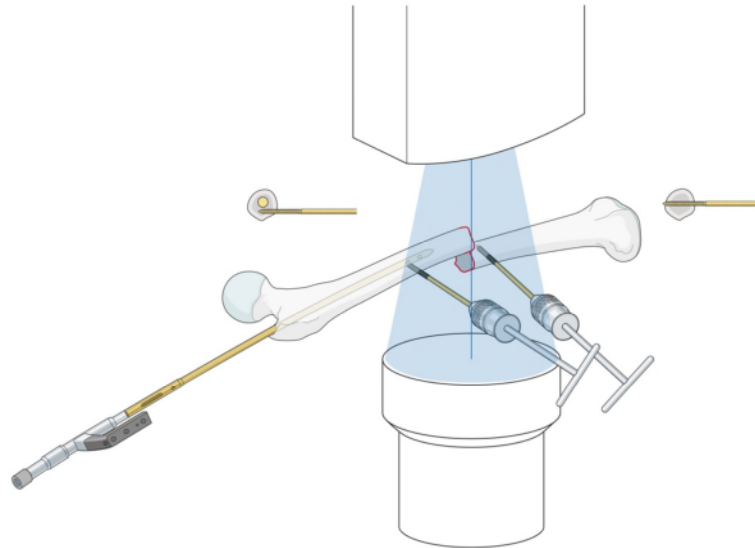
So called Poller screws support the reduction.

Nail can not pass the fracture zones but will be directed into IM canal.

1. Reduction

Indirect—closed:

- Before operation
 - Traction table
- During operation
 - Large distractor
 - Poller screws
 - Joysticks



Joysticks help to manipulate/reduce the fracture

1. Reduction

Indirect—closed:

- Before operation
 - Traction table
- During operation
 - Large distractor
 - Poller screws
 - Joysticks

Direct—open:

- Small incision into fracture zone
- Rarely used

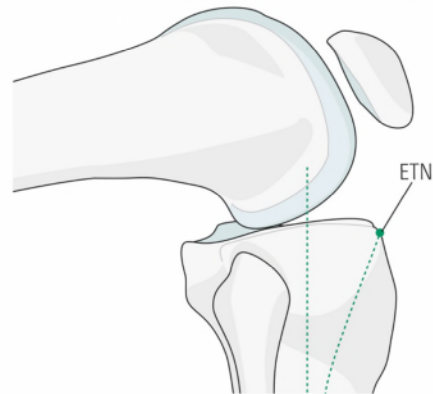
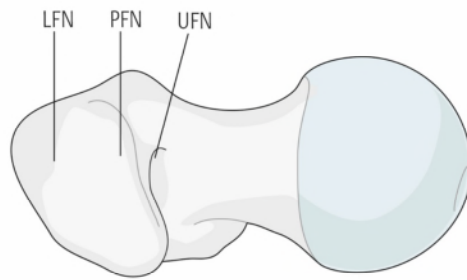
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In some cases, though seldom an open reduction may be necessary due to failed closed reduction .

2. Opening of canal

Correct entry point depends on:

- Anatomical region
- Type of nail



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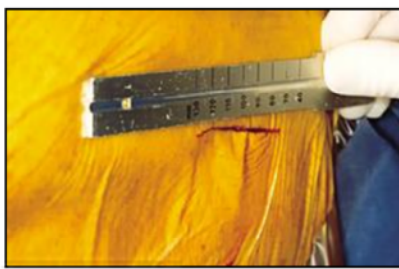
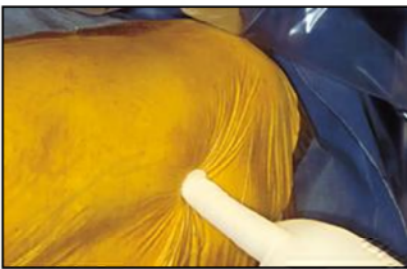
The entry point is for each anatomical region defined and depends on the type of nail.

Different nails require different entry points, particularly in the femur. It is important that the surgeon is aware of this as part of the planning process.

2. Opening of canal

Correct entry point depends on:

- Anatomical region
- Type of nail
- Is crucial for success



AO

In the femur, flexion and adduction of the hip joint facilitate the approach for antegrade nailing. This measure decreases the length of the incision, especially in obese patients. The greater trochanter, lateral femoral condyle, and, if possible, the femoral shaft, are palpated and, if necessary, identified with a marker. A slightly curved line is drawn in a proximal direction corresponding to the curvature of the femur. A stab-incision about 3–5 cm long is made approximately 10 cm above the tip and towards the greater trochanter. This allows insertion of a palpating finger alongside the implant. Incisions should not be placed too posteriorly, since abductor muscle weakness has been recorded after nailing.

2. Opening of canal

Risks of incorrect entry:

- Malalignment
- Difficulty to insert the nail
- Extension of the fracture
- Problems with proximal locking
- Articular damage

AO

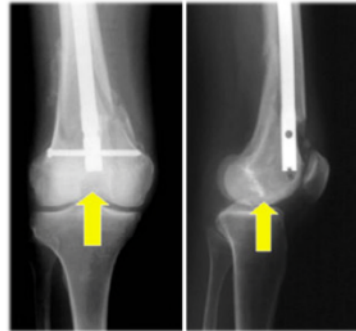
The entry point will determine the nail's path down the intramedullary canal. Therefore, finding and knowing the correct entry point is the most critical step of the procedure. If the entry point is wrong, the nail may deform the fracture site, get stuck and even cause additional fractures.

Other risks are:

- Malalignment
- Difficulty to insert the nail
- Extension of the fracture
- Problems with proximal locking
- Articular damage

2. Opening of canal

In this case of retrograde nailing, the entry point was too anterior and caused an additional femoral fracture.



AO

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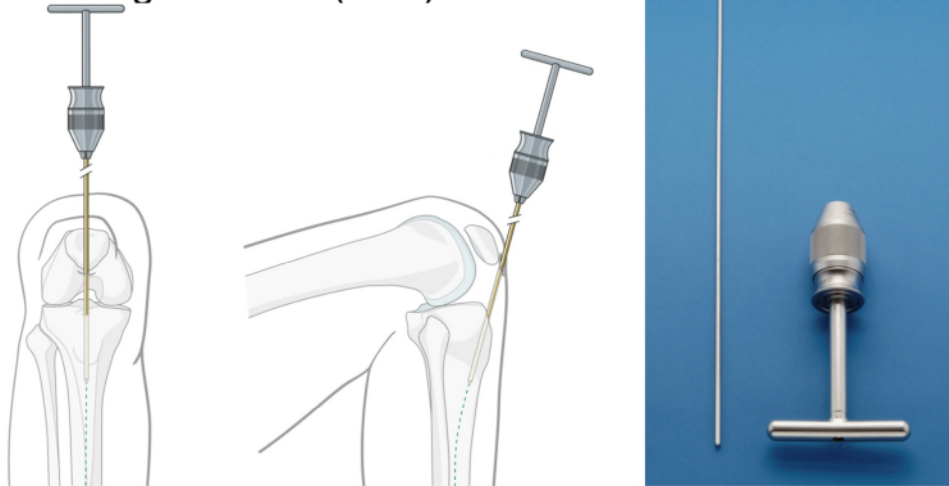
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Other risks are:

- Malalignment
- Difficulty to insert the nail
- Extension of the fracture
- Problems with proximal locking
- Articular damage

2. Opening of canal

1. Insertion of guide wire (tibia)

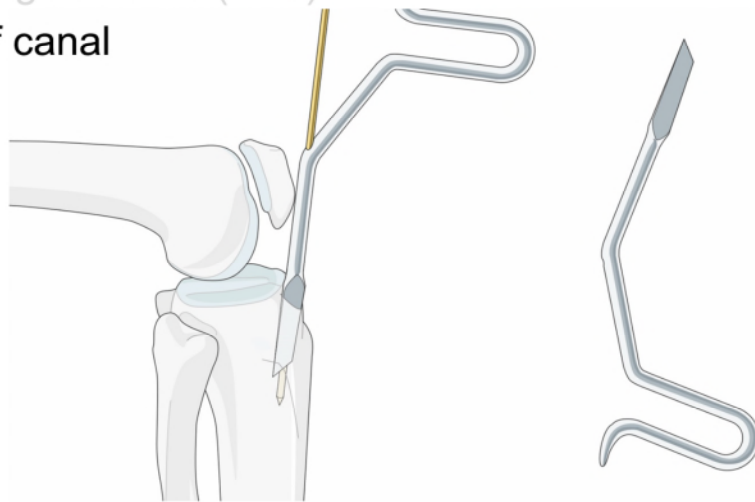


AO

Once the incision has been made and the correct entry point defined, the guide wire will be inserted. This is done manually using a T-handle with universal chuck.

2. Opening of canal

1. Insertion of guide wire (tibia)
2. Opening of canal

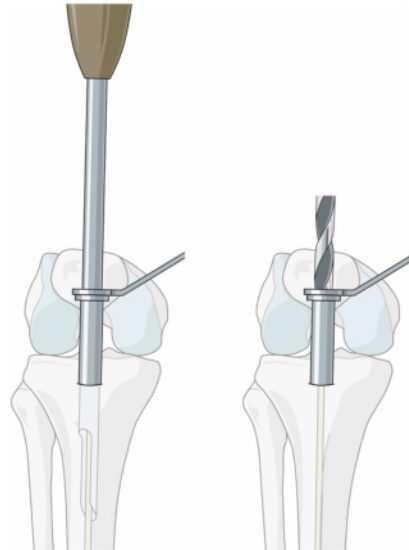
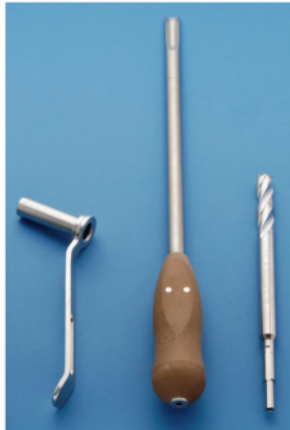


AO

The old, well-known, classic awl can be used.
Here it is a cannulated version.

2. Opening of canal

1. Insertion of guide wire (tibia)
2. Opening of canal



AO

There are several possibilities to open the intramedullary canal:

1. A hollow chisel can be used.
2. A drill bit with sleeve can be used.

3. Reaming

- Insertion of reaming rod
- Size and length depend on:
 - Type of nail
 - Reamer set
- Used for reduction and for reaming



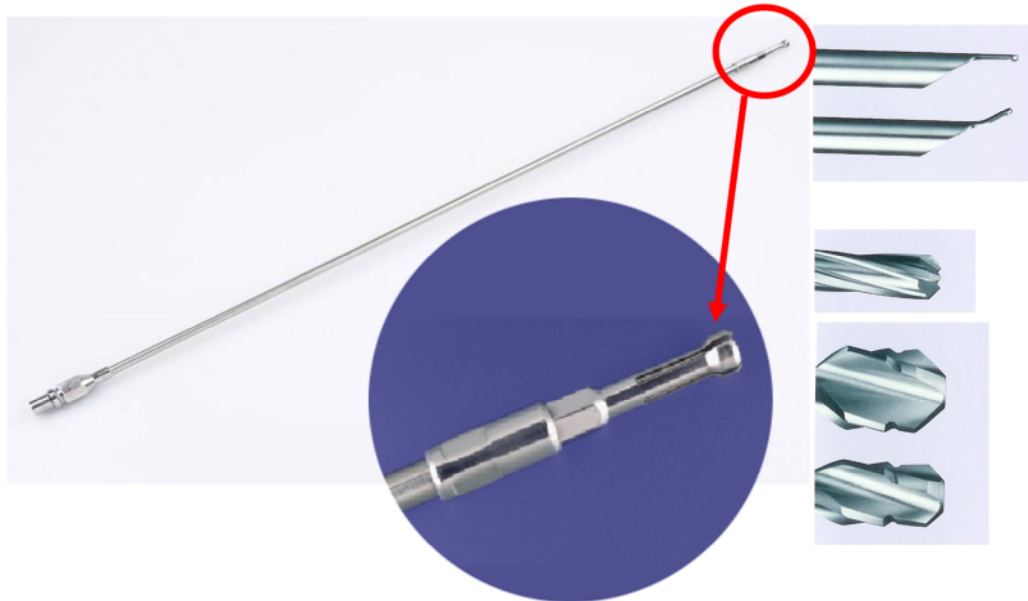
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The correct reaming rod is inserted. The rod has a “ball tip” at the end and avoids loss of reaming heads in the intramedullary canal.

The size and the length of the reaming rod depends on the type of the nail and reamer set.

The rod for a femoral nail will be longer than for a tibial nail.

3. Reaming



AO

A flexible shaft with reduction head, or reamer head, is inserted over the reaming rod.

- The reduction head can be used to reduce the fracture.
- The reamer heads are clicked onto the tip of the flexible shaft.

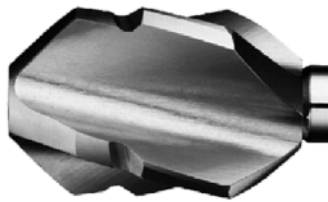
3. Reaming

First reamer head to be used is front-cutting



8.5 mm

Next reamer heads to be used are side-cutting (front is blunt)



9.0 – 19.0 mm

Overream to 1mm larger than diameter of nail

AO

First the front cutting reamer head is used because it will cut the pathway for the next reamer heads.

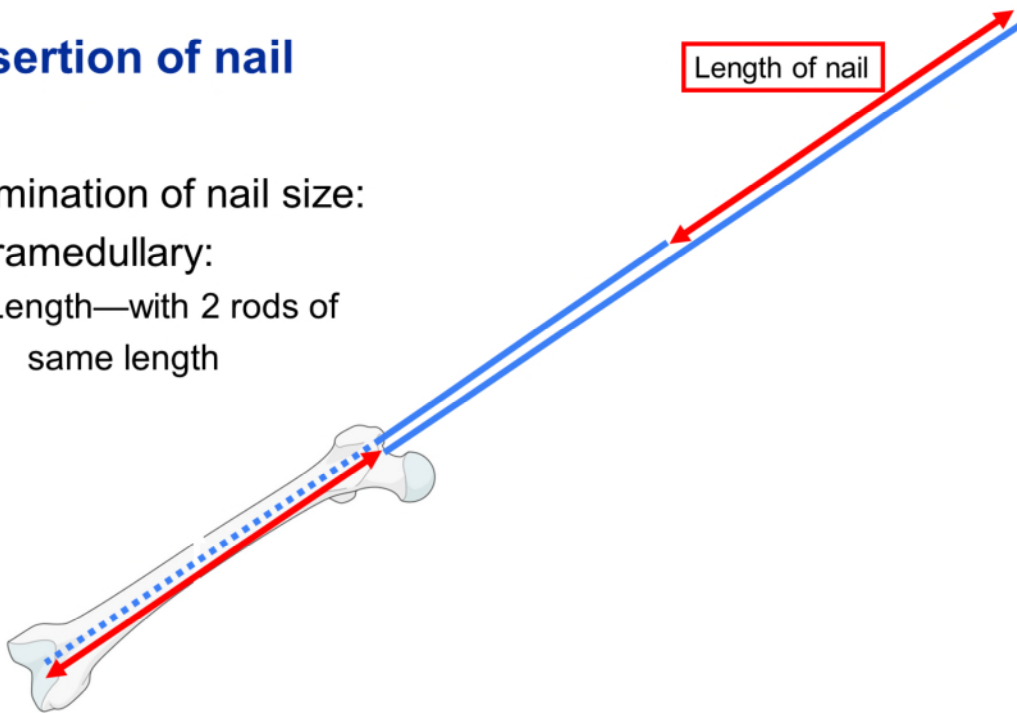
Then side cutting reamer heads are used step by step with increments of 0.5 mm.

The last reamer head should be 1mm larger than the determined nail size.

4. Insertion of nail

Determination of nail size:

- Intramedullary:
 - Length—with 2 rods of same length



The length and diameter of the nail can be determined intramedullarily, or extramedullarily.

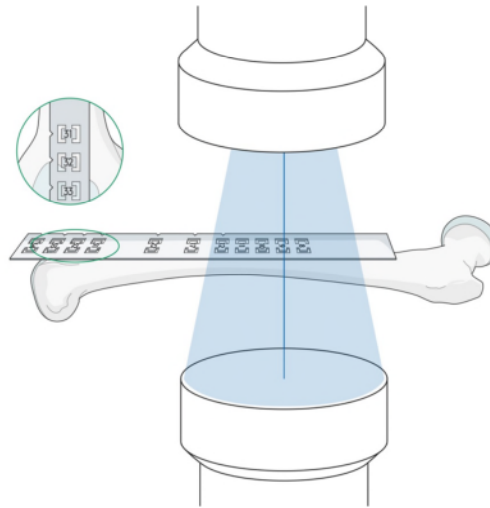
Intramedullarily:

1. Reaming rod is pushed to the end of the medullary canal.
2. Reaming rod of the same length is used outside the IM canal and held at the level of the entry point, just next to the first rod.
3. The difference between the two rods will determine the nail length.

4. Insertion of nail

Determination of nail size:

- Intramedullary:
 - Length—with 2 rods of same length
- Extramedullary:
 - Length
 - Size



AO

Extramedullary:

Both length and diameter can be measured by using a radiographic ruler.

When positioned correctly on the leg, and using the image intensifier, the length and diameter can be determined.

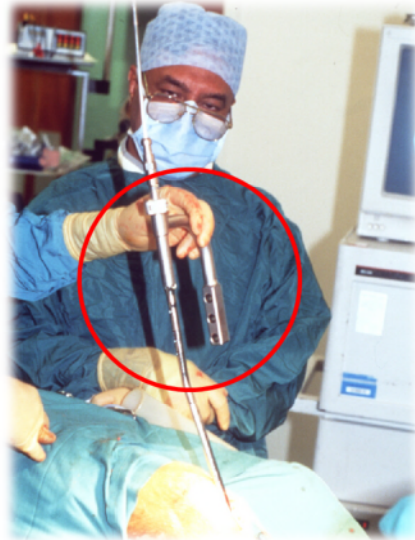
4. Insertion of nail

Instruments needed:

- Handle
- Connecting screw
- Hammer

Image intensifier:

- To determine correct intramedullary insertion



AO

Once the medullary canal has been reamed (if required), the nail can be inserted.

The nail will be attached to its handle with a connecting screw.

It is important to respect the correct use of instruments. Some handles must be inserted manually. A hammer can be used but only on the specific, defined places on the handle. The handle can be easily damaged with hammer blows to the wrong places.

It is recommended that the start insertion with manual manipulations and not hammer blows.

5. Locking of nail

Why interlocking of a nail?

1. To get primary bone healing
2. To avoid malrotation of the limb
3. To provide absolute stability



AO

Optional:

Insert questions to check learning

5. Locking of nail

Why interlocking of a nail?

1. To get primary bone healing

2. To avoid malrotation of the limb



3. To provide absolute stability



AO

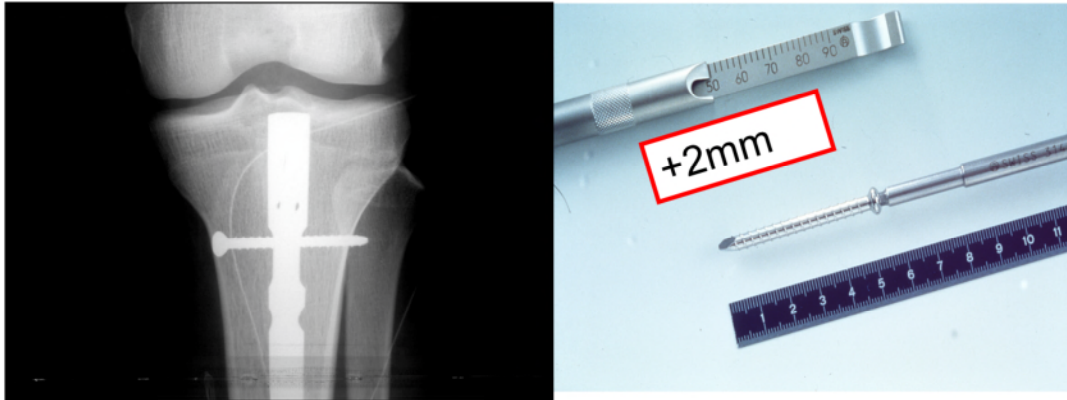
Optional:

Insert questions to check learning

5. Locking of nail

Which bolt size? Which drill bit?

Which bolt length?



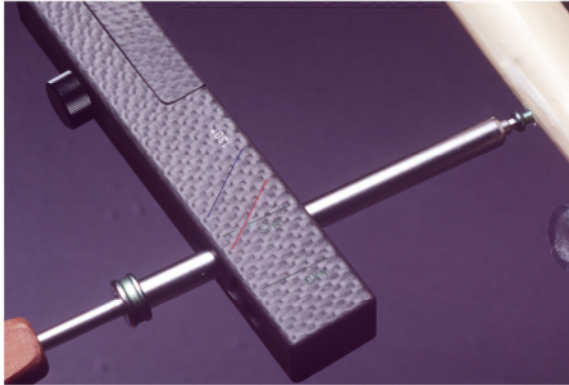
The diameter of the drill bit to be used depends on the diameter of the locking bolt and this may be different for each type of nail.

In general the bolt to be inserted will be approximately 2 mm longer than the measured hole depth.

5. Locking of nail

Proximal:

- Aiming arm
- Triple drill sleeve
- Drill bit



AO

The proximal locking is done with an aiming arm. This arm is connected to the insertion handle, and the triple drill sleeve inserted.

The triple drill sleeve contains:

- A trocar for the location of the incision
- A drill sleeve
- A wider sleeve for the insertion of the screw.

5. Locking of nail

Distal:

- Radiolucent drive
- Pointed drill bit



AO

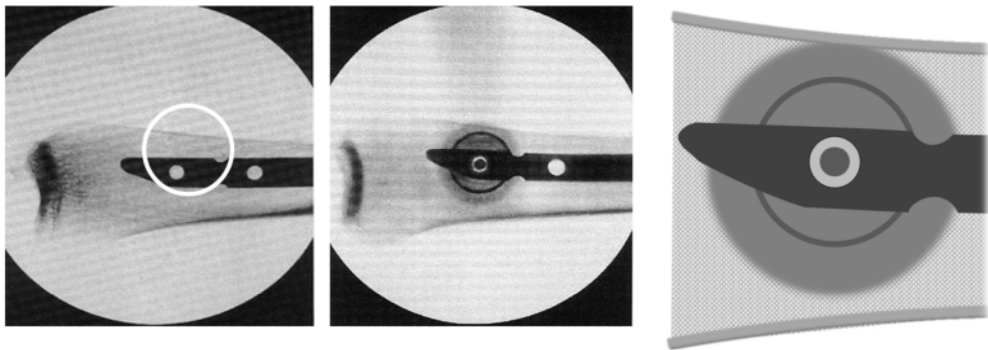
For both, proximal and distal locking, a specially-designed drill bit is used. The drill bit is pointed so as to avoid sliding off the bone at the start of the drilling process. The cutting edge is kept short in order to decrease damage to soft tissue.

The same type of drill bit is required for distal locking. These drill bits are also radiolucent and can be used with the radiolucent drive, as explained on the next slide.

5. Locking of nail

Distal:

- Radiolucent drive
- Pointed drill bit
- Correct projection with image intensifier



These pointed drill bits are also radiolucent, in order to be used with the radiolucent drive.

Note on dynamization:

Dynamization is the removal of one set of screws during the healing process. Extra movement will allow callus formation, this in case of delayed union.

5. Locking of nail

- Insertion of nail end cap



AO

At the end of nail insertion, an end cap can be screwed into the nail. This avoids tissue ingrowth and allows easier removal of the nail once the fracture is healed. The end cap can be of different sizes, depending on the length of the nail.

6. Final check

Reduction:

- Alignment
- Angulation
- Rotation

Fixation:

- Interlocking of bolts
- Fracture pattern



AO

In all cases a final control x-ray must be taken at the very end of the procedure.

Summary

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

- List indications for an osteosynthesis with an intramedullary nail
- Explain how an intramedullary nail works
- Discuss the design of different nails
- Describe the surgical technique

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