

Principles of intramedullary nailing

Paulo Barbosa

Disclaimer

All contents of this study guide are owned by AO Foundation/AO Trauma and cannot be used for any other than private purposes. This work may only be used for your private education.

How to use this handout?

This handout is part of the AO Trauma Course for ORP. The left column is the information as it may be given during the lecture. The column on the right gives you space to make personal notes.

Learning outcomes

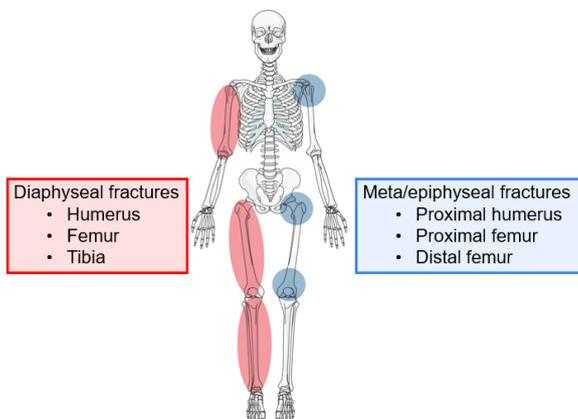
At the end of this lecture you will be able to:

- 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

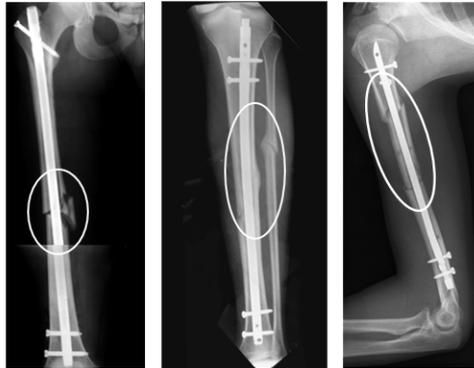
Indications

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

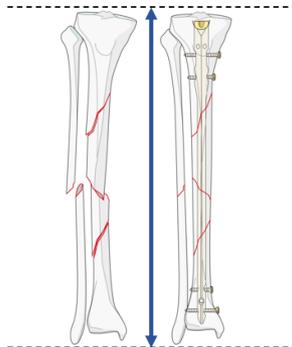


The intramedullary nail is mainly used for fractures of long bones.

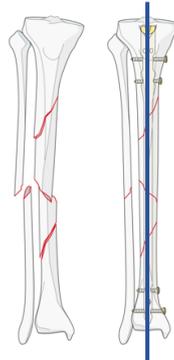


2. Objectives of treatment with a nail

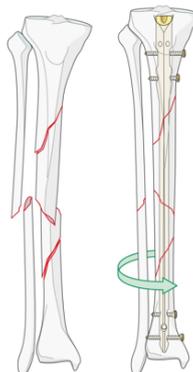
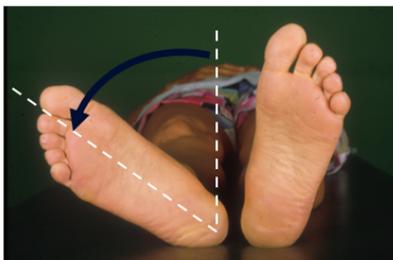
1. An intramedullary nail acts as a splint. It's function is to **restore the length** of limb, ...



2. ...to **restore the load axis**,...



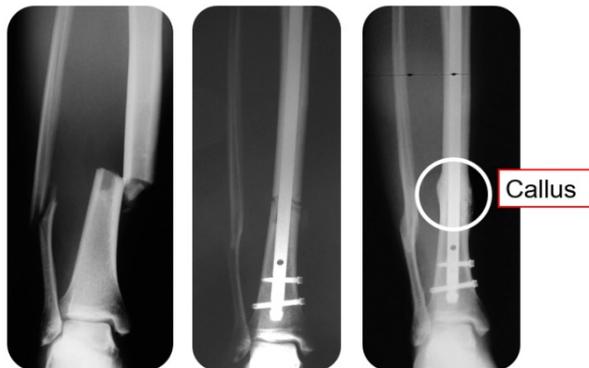
3. ...and to **avoid any malrotation**.



3. 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.



4. Static and dynamic interlocking of nails

1. Static interlocking

Static interlocking is used in severe fractures with rotational and/or longitudinal instability.

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



2. Dynamic interlocking

In simple shaft fractures dynamic interlocking is used.

It increases compression in the fracture zone, controls rotational instability and encourages callus formation. One bolt only is used proximally and one distally in longitudinal elliptical slots.



Weight bearing will allow the proximal bolt to move in the oval nail slot and encourages interfragmentary compression.



Callus is formed.



5. Reaming

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.



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



• Blood supply in **reamed** technique



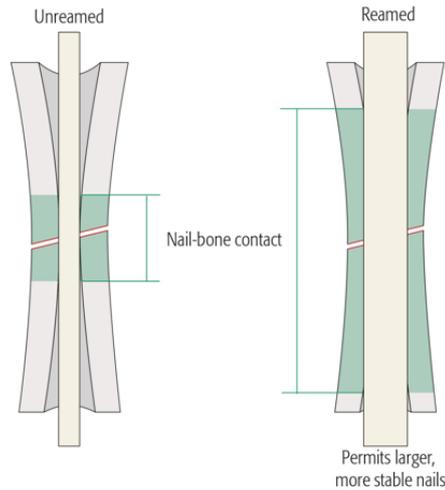
• Blood supply in **unreamed** technique

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

So, 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.



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.

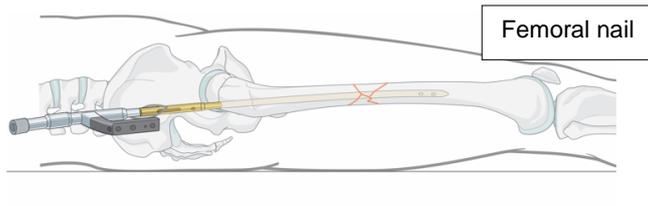
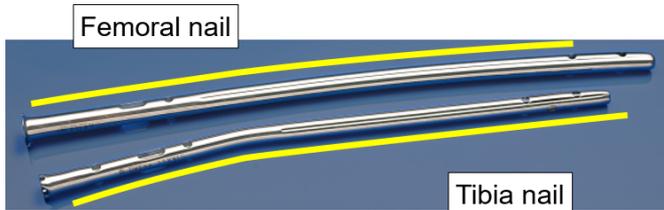
Reaming is preferable, however contra-indications must be respected. Reaming should be kept as short as possible, or even avoided, in severely injured patients, or patients with a significant lung injury.

	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

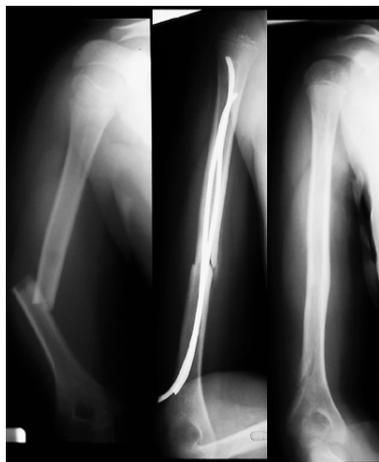
Brumback et al (J Am Acad Orthop Surg. 2000;8:83–90)

6. Type of nail

The design of the nail will depend on the anatomical 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.

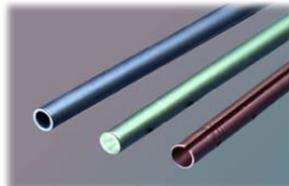


Titanium elastic nails (pictures on the right and below) can be used in different anatomical regions. They are however mainly used in children.



Design of nails

- Cannulated
- Solid
- Hollow and slotted



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.



Material

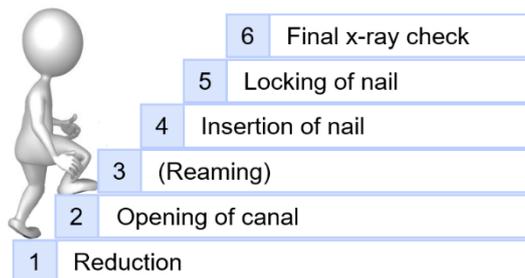
- Titanium
- Stainless steel

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.

7. Technique of intramedullary nailing

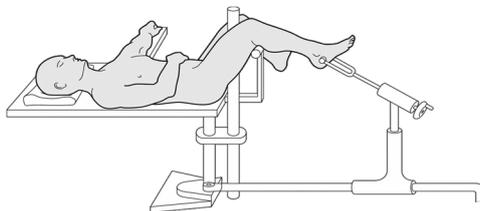
The surgical technique consists of a maximum of 6 steps.

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 is inserted.
5. The nail is locked if required (proximally and distally).
6. Final x-ray control is done.

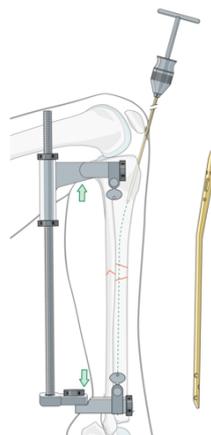


1. Reduction

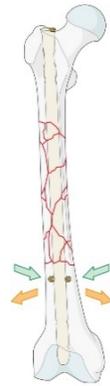
The fracture will be reduced closed, thus indirectly. In some cases, a **fracture table** may be used: e.g., fracture of the proximal femur, tibia shaft (less common), etc.



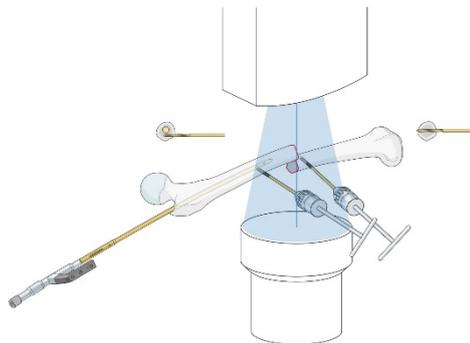
An **external large distractor** may help to achieve the reduction process in a gentle and controlled process.



Also so called **Poller screws** support the reduction. Nail can not pass the fracture zones but will be directed into IM canal.



Joysticks help to manipulate/reduce the fracture.

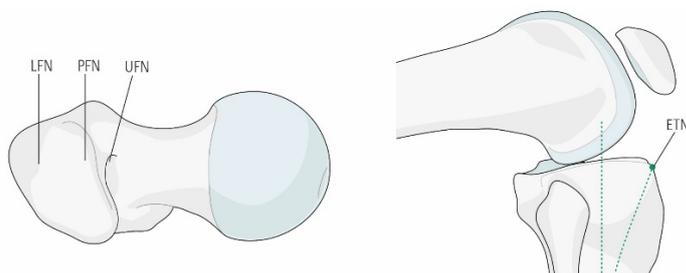


In some cases, though seldom, an open reduction may be necessary due to failed closed reduction.

2. Opening of canal

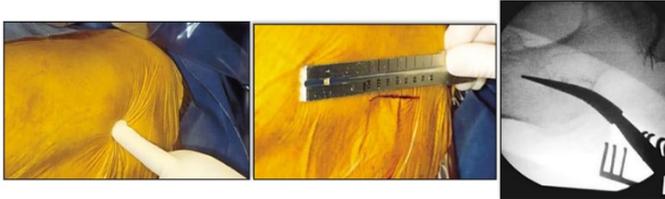
The entry point is for each anatomical region defined and depends on the type of nail.

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.



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.



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



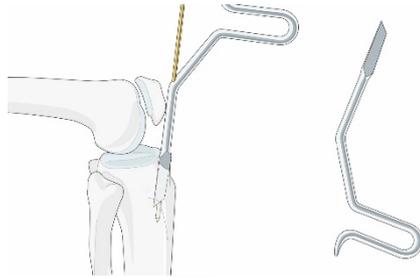
1. Insertion of guide wire

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.



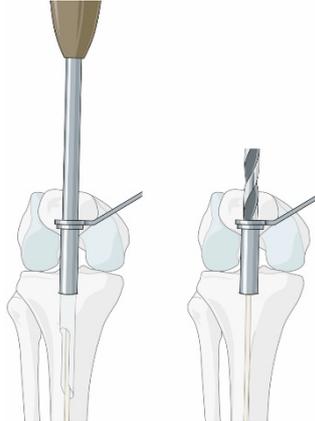
2. Opening of canal

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



There are several possibilities to open the intramedullary canal:

- A hollow chisel can be used.
- A drill bit with sleeve can be used.



3. Reaming

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.

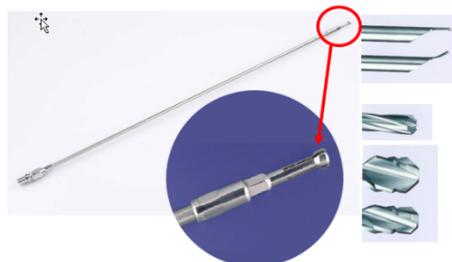
The rod for a femoral nail will be longer than for a tibial nail.



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.

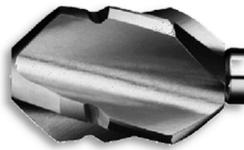
The reamer heads are clicked onto the tip of the flexible shaft.



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.



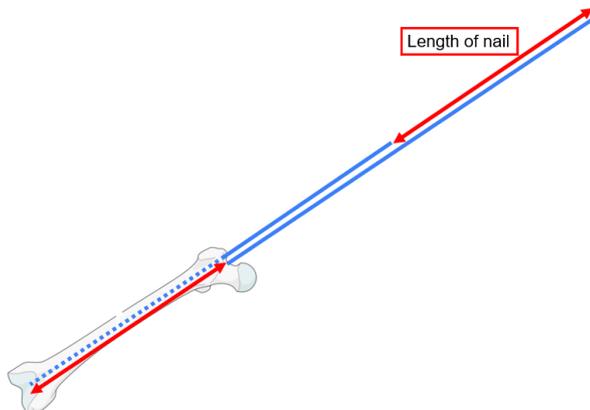
The last reamer head should be 1mm larger than the determined nail size.

4. Nail insertion

1. The **length and diameter** of the nail can be determined.

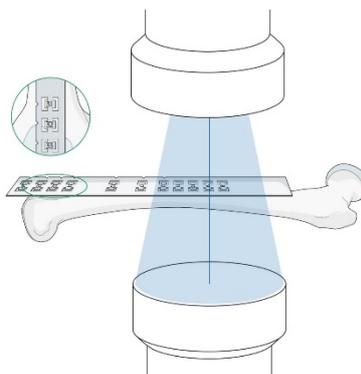
Intramedullarily

- One reaming rod is pushed to the end of the medullary canal.
- A second 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.
- The difference between the two rods will determine the nail length.



Extramedullarily

- 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.



2. The nail is **inserted**.

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.

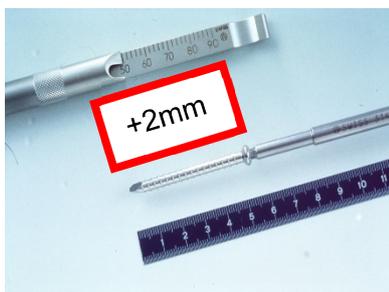
It is recommended that the start insertion with manual manipulations and not hammer blows.



5. **Interlocking of the nail**

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.



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



For both, proximal and distal locking, a specially designed drill bit is used. The drill bit is pointed 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.

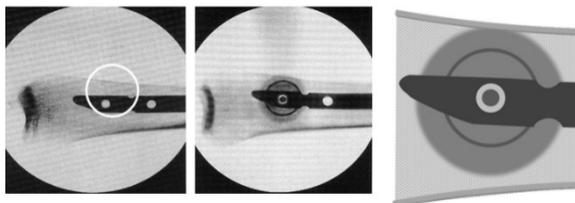


The same type of drill bit is required for distal locking. These drill bits are also radiolucent and can be used with the radiolucent drive, as explained on the next slide.

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.



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

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

Checked are

1. Reduction:
 - Alignment
 - Angulation
 - Rotation
2. Fixation:
 - Interlocking of bolts
 - Fracture pattern



Summary

You should now 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

Questions

IM nails are used for the following type of fracture

- A fracture involving the joint
- An intracapsular hip fracture
- A diaphyseal long bone fracture

IM nails require the following type of fracture reduction

- Restoration of length, alignment and rotation
- Restoration through anatomical reduction
- Restoration through absolute stability

What is the purpose of the olive tip on the guide wire?

- To allow easy passage of the guide wire into the canal
- To prevent over reaming of the canal
- To prevent the reamer advancing to far

Why interlocking a nail?

- To get primary bone healing.
- To avoid malrotation of the limb.
- To provide absolute stability.

Reflect on your own practice:

Which content of this lecture will you transfer into your practice?