Principles of intramedullary nailing
Paulo Barbosa

Author
• Paulo Barbosa, Brazil

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• Klaus Dresing, Germany
• Markus Arand, Germany

Editor
• Chris Colton, United Kingdom
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

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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

Intramedullary nails are mainly used for fractures of:
- Femur (proximal, distal and shaft)
- Tibia (shaft)
- Humerus (shaft)
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

...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

…and to avoid any malrotation.
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 Küntsch (1900–1972)

- No interlocking of his original nails
In order to solve the rotational problems interlocking options were created.

Static and dynamic interlocking of nails

• What does it mean?
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.
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.
Weight bearing will allow the proximal bolt to move in the oval nail slot and encourages interfragmentary compression (bone healing with callus).
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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 show the difference of blood supply in reamed and unreamed applied techniques. The blood supply in unreamed techniques is less compromised.

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

**Reference:**

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.
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These are solid thin nails used often in children.

**Type of nails Example**

Titanium elastic nails (TENs):
- For different anatomical regions
- Mainly in children

[Image of nails and X-rays] Courtesy: Dr. Teddy Slonigo, Bern
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.
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 intramedullary canal is reamed.
4. The nail inserted.
5. The nail locked if required (proximally and distally).
6. Final x-ray control
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.
Here an external large distractor helps to achieve the reduction process in a gentle and controlled process.
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

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

2. Opening of canal

- Correct entry point depends on:
  - Anatomical region
  - Type of nail
  - Is crucial for success
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
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2. Opening of canal

1. Insertion of guide wire (tibia)

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

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.
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

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.
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

Optional:
Insert questions to check learning
5. Locking of nail

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

6. Final check

- Reduction:
  - Alignment
  - Angulation
  - Rotation

- Fixation:
  - Interlocking of bolts
  - Fracture pattern
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