INTRAMEDULLARY NAILING OF FEMORAL SHAFT FRACTURES

Intramedullary (IM) nailing is an effective method of treating femoral shaft fracture and has become one of the preferred procedures in orthopaedics.
In general, IM nailing is associated with high union rates and low complication rates.

Debate	Antegrade versus retrograde nailing
	Antegrade nailing through a piriformis fossa versus a trochanteric entry nail.
	Whether to position the patient supine or lateral
	With or without traction
	With or without reaming.

BASIC SCIENCE

Normal intramedullary pressure	30-50 mmHg
IM reaming	800 mmHg
Preparation for the canal for noncemented prosthesis	800 mmHg
Prosthetic insertion in cemented prosthesis	1400 mmHg

IM rod Reaming Vs Nonreaming: Technically Reaming is better although there may be some physiological disadvantages (emboli to lungs) but this has not been proved well.

With newer designs of the reamer, intramedullary pressure can be reduced:

a. Increase in gap length: Power 3

b. Decrease in the length of seal (short reamer with sharp, deep flutes)

c. Reaming with less compression force

A & B & C increases black flow and decreases IMP

Bixcut Synream AO Universal

A study by Mousavi [*Clin Orthop Relat Res*. 2000;373:295-303] showed
that the lowest intramedullary pressures were generated at high revolution rates with low driving speeds and that these facts were most important during the initial stages of reaming when pressures were found to be particularly high. They also found that the use of small core diameter reamers resulted in lower pressures. They therefore recommended that reaming should be performed with reamer heads of a small core design at a continuously high revolution rate but at a low driving speed – a variable that can be adjusted by the surgeon.➔

Working Length

In comminuted fracture: the length of a nail between the most proximal point of fixation in the distal fragment [a] and the most distal point of fixation in the proximal fragment [b].

The unsupported portion of nail between the bone fragments. Bending stiffness is inversely proportional to the square of the working length.
Torsional stiffness s inversely proportional to the working length
For a fracture located within 5 cm of the most proximal distal locking screw, the peak stress around the hole may exceed the endurance limit of the metal. The nail is loaded as a Cantilever beam.

- **Nail Diameter**

Bending stiffness is radius to the power 4
Slotted nail is 40 times decrease in torsional stiffness
The cross-sectional shape also affects the bending and torsional stiffness.
Distribution of material: A wider diameter hollow tube is stiffer than a solid smaller diameter tube with the same *amount of material*, and the outer fibre stress for a given bending moment is reduced. (This is why bones have a medullary canal). This is more Efficient. This is defined by the second moment of area (I) [A property which measures the distribution of the material around the cross section].
Tubes with a wall thickness: radius ratio of less than one eighth tends to behave as curved sheets rather than tubes. These thin-walled tubes are subject to buckling. (Bone is thick-walled).

Bending Strength

Radius to the power 4
Bending moment of adult femur is 250 Nm
Load the femur must sustain during walking is 125 Nm
Smallest GK (Grosse - Kempf) nail capable of sustaining this load is 13 mm

Rigidity

Inversely proportional to the cube of the working length
Torsional Rigidity
Torsional rigidity increases with the R4. Therefore if the radius of a nail is doubled the Torsional rigidity increases by a factor of 16.

Polar moment of inertia

Measure of the Torsional Stiffness of a column/ shaft

- **Rhinlander's Study**

  Circulation of inner 2/3 rd of the cortex is by nutrient vessel

  Centrifugal distribution: predominant from centre to periphery [Normal]

  In fracture healing it is centripetal [outside to centre]

Research

1. Animal study: Reamed nailing: Cortical revascularization in 12 weeks

   Unreamed nailing: 6 weeks in Sheep model.

Animal study: Reamed nailing increased periosteal blood supply[reamed > undreamed].

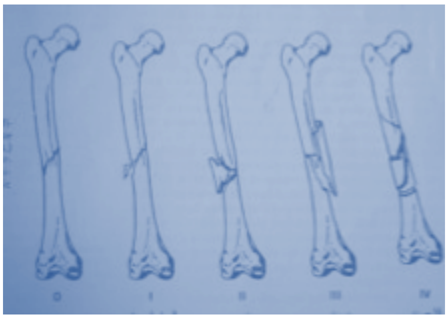
Callus strength is same for reamed and undreamed

Clinical: Union rate is 97-100%

2. Physiology of Reaming

1. Damages the endosteal circulation
2. Enhances periosteal circulation (Reichert)
3. Overall blood supply is maintained
4. Extruded marrow: osteoinductive and is useful in non-union and infection
5. Effect is not same in open fracture.
6. Equivalent effect in tibia and femur

Classification: Winquist



0 No comminution
I Small butterfly
II >50% cortex intact
III <50% cortex intact
IV No contact: complete comminution

Technique of Nailing

A superficial analysis of union rates of antegrade nailing compared with retrograde nailing shows contradictory results. Early studies of retrograde nailing revealed nonunion rates greater than those typically reported in published series of ante-grade nailing. The relatively low union rates seen in early series of retrograde nailing were likely related to the use of a nonreaming technique and small-diameter nails relative to the diameter of the femoral canal. Retrograde nailing using modern techniques that include reaming, snug-fitting nails, and interlocking screws is associated with union rates similar to those for antegrade nailing. More complications related to the

Patient Positioning

One common setup for antegrade nailing involves positioning the patient supine on a fracture table. Skin traction is applied to the foot, which is secured in a boot. Skeletal traction is usually not required. The noninjured leg may be in the hemilithotomy position, widely abducted.

The well leg should be carefully monitored to avoid the development of compartment syndrome.

Antegrade Nailing Retrograde nailing

Check reduction [crutch support is useful for reduction]

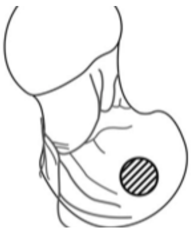
Proximal interlocking

Target device

At lesser trochanter

It is easy: Make sure Guide wire is out of the nail is out of the nail and proximal fixation bolt is tight.

Antegrade Nailing



Piriformis Starting Point Vs Trochanteric

Antegrade IM nailing through the piriformis fossa is associated with healing rates as high as 99% and with low complication rates. The piriformis fossa starting point has as its main advantage a collinear trajectory with the long axis of the femoral shaft. This reduces the risk of iatrogenic fracture comminution and varus malalignment compared with "off axis" starting points, such as the trochanteric entry portal.

Disadvantages of the piriformis starting point include
1. The relative technical difficulty in obtaining such a starting point compared with retrograde and trochanteric portals, especially in obese patients.
2. Increased risk of iatrogenic bursting of the proximal segment. The trochanteric portal, given its more cancellous nature, is more forgiving with regard to generation of hoop stress,such that a relatively anterior starting point in the trochanteric region is acceptable.
Implants specifically designed for trochanteric insertion [TAN], with a proximal lateral bend, combined with modified insertion technique, have been shown to essentially eliminate varus malalignment and iatrogenic comminution.
The lateral proximal bend of trochanteric nails reduces the risk of varus malalignment. However, it is critical that the starting point not be too lateral. In fact, the tip of the greater trochanter is not necessarily the proper landmark for the starting point.

A subtle, but important, modification of standard nailing technique can also help avoid iatrogenic comminution. This modification leverages the anterior bow of the nail. Rotation of the nail 90° upon insertion, such that the anterior bow is apex medial, directs the tip of the nail centrally. After the nail crosses the fracture, it is derotated.
The lateral trochanteric entry point is offset approximately 12° to the anatomic axis of the femur.

Starting point for Retrograde Nailing

Retrograde nailing is an alternative to antegrade nailing. Proper technique includes an insertion site in the intracondylar notch at the apex of the Blumensaat's line, which is approximately 1 cm anterior to the posterior cruciate ligament origin. With this as the starting point, the trajectory for nail insertion should be collinear with the long axis of the femur in both the anteroposterior and lateral planes. The distal end of the nail must be buried beneath the subchondral bone.

At least two distal interlocks should be used to minimize the risk of secondary telescoping of the nail into the knee joint. This complication can occur after fracture of the distal interlocking screws associated with comminuted, axially unstable fracture patterns.

Confirm Position of the guide wire:
Confirm position of the fracture on I.I
Starting point and pass the guide wire [if Hand instrument available as in TAN nail: use it as it is easy to direct the guide wire with the help of this instrument]
Guide wire position should be in the centre at the distal end so the reaming is going to be centric. If there is eccentric position withdraw the guide wire and use the blocking screw [alternatively ream proximal and push the "Hand" distally to get the guide wire in centric position

Measure the length of the guide wire.

Sequential reaming starting from 7.5 mm

Do not ream at the comminuted fracture site

1mm smaller sized nail should be used

Release the traction after nail has enter distal fragment

Back slap technique can be used after distal screw fixation

Finally fix the proximal interlocking screw.

Reaming

1. There has been concern about the systemic effects of reaming on multi-trauma patients, especially those with pulmonary injury.
2. In animal models, reaming has been shown to increase IM pressures, increase pulmonary artery pressures, and be associated with fat embolization.
3. Several studies have demonstrated only limited and transient effects of emboli on the development of adult respiratory distress syndrome and further systemic compromise.

Reaming has been shown to cause variable grades of endosteal thermal damage and disruption of the endosteal cortical blood flow in animal studies, effects that, in theory, would be detrimental to fracture healing. Thermal necrosis should be avoided. Excessive cortical reaming generates significant heat because of the relative hardness of the endosteal cortical bone.

Modern reaming technique calls for minimal (0.5 to 1 mm) reaming beyond the occurrence of cortical chatter at the level of the isthmus. The proper nail diameter for a snug fit is therefore 1 to 1.5 mm smaller than the largest reamer used, a width that also correlates to the diameter of the isthmus. Such undersizing of the nail is required to avoid iatrogenic bursting of the femoral canal because of mismatch of femoral and nail bows.

Hole is not round: With the introducer twist the nai to get hole round and then check rotation and start entry hole

Distal interlocking screw: Injury, Int. J. Care Injured (2006) 37, 109—119

My preference is “Free hand”

1. Image intensifier positioning is important
2. Always obtain a round hole imaging and not oblique
3. Beware of radiation
4. Always check in AP and Lateral
5. Can be done with or without target device
6. Personal preference is free hand using handle of the artery
7. Stab incision and blunt dissection of the tissue to the Bone

8. Confirm starting drill point in the centre of the hole [orientate in AP and lateral images] and roughen the cortex with a Steinman Pin and then drill
9. Note the direction of the drill and depth measure and 2mm longer screw in the same direction