Module: #10 - Trochanteric Fixation Nail

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Summary: Students will design and manufacture a trochanteric fixation nail (TFN) and use it to repair an intertrochanteric fracture. The instructor will provide an overview of the anatomy of the hip joint, common types of hip fractures, and different repair strategies based on fracture type. Students will be provided with plastic tubing and household hardware and asked to design and construct a TFN, using an actual implant as a model. After creating and installing their TFN, students will test the functionality of their design by creating an intertrochanteric fracture and seeing if the femoral head compresses against the greater trochanter. Students will compare and contrast their implant design with an actual TFN and suggest design improvements to the implant itself as well as installation tools.

Learning Objectives
• Understand basic biomechanical principles behind intramedullary fixation
• Apply measurement and problem-solving skills to create a trochanteric fixation nail (TFN) design
• Gain confidence in manual skills, including power drills and oscillating saw (multi-tool)
• Apply critical thinking skills to brainstorm design improvements to the TFN itself as well as any custom tools to install the nail

Teaching Aids
• 8.5 x 11” laminated slides
• Demonstration Models
  1. Intact proximal femur with cut-aways showing cortical and trabecular bone
  2. Trochanteric fixation nail (long & short nail; nail inserted into Sawbones)
  3. Proximal femur repaired with TFN built from semi-rigid plastic tubing and lag screw

Detailed Instructions
1. Overview from Instructor
  1.1. (Model #1, Slides #1 & #2) Identify/define the following:
     1.1.1. Anatomical directions: proximal/distal, anterior/posterior, medial/lateral, varus/valgus
     1.1.2. Femoral head and neck, greater and lesser trochanter, femoral shaft (diaphysis)
     1.1.3. Cortical and trabecular bone
     1.1.4. Joint capsule & ligaments
  1.2. Basic Biomechanics & Hip Fractures
1.2.1. *(Model #1)* Load transferred from hip socket (acetabulum) to femoral head, down the neck, and through the trochanter to the shaft

1.2.2. *(Slide #3)* Hip fractures commonly occur with fall to the side, impacting on the greater trochanter

1.2.3. Fracture Types & Treatments
   1.2.3.1. Explain open versus closed fracture reduction
   1.2.3.2. *(Slide #5)* Neck fractures (AO 31-B) – fixed with dynamic hip screw (DHS) or lag screws
   1.2.3.3. *(Slides #4-5)* Head fractures (AO 31-C) – fixed with cortical screws
   1.2.3.4. *(Slide #6)* Trochanteric fractures (AO 31-A) – fixed with dynamic hip screw (DHS) or Trochanteric Fracture Nail (TFN)

1.2.4. *(Model #2 & Slide #6)* TFN Design & Function
   1.2.4.1. Nail inserted through greater trochanter into femoral diaphysis
   1.2.4.2. Large femoral screw (“blade”) interlocks with nail and penetrates through neck into femoral head
   1.2.4.3. Screw slides within nail, allowing “dynamic compression” across fracture line. This promotes fracture healing.

2. Case Presentation & Surgical Treatment
   2.1. *(Slide #4)* Patient presents with trochanteric fracture (AO Type 31-A). Treatment with TFN is recommended.
   2.2. Key observations from surgery
      2.2.1. *(Model #3)* TFN created using standard household hardware. Allows movement across fracture line.

3. Logistics
   3.1. Students are divided into small groups of 3-4 students and given an intact model of the proximal femur.
   3.2. At least one fully trained volunteer should be present at each station due to heavy use of power equipment.
   3.3. Students are guided through Steps 5-8 in small groups.

Discussion Point
Q. Identify whether you have a right or a left femur.
A. Depends on the model. The lesser trochanter faces posteriorly.

4. Safety
   4.1. Plastic tubing and femur should be held in clamp-on vise during drilling operations.
   4.2. Safety goggles should be worn at all times when drilling.
   4.3. This workshop involves use of the oscillating saw (multi-tool). Students should be given a demonstration of use of this tool. Safety goggles must be worn at all times when using oscillating saw.
5. TFN Nail Design & Manufacture
   5.1. Students are provided with a kit containing household hardware, specifically, plastic tubing and lag and fully threaded screws of various lengths. They are to construct a TFN using this hardware.
   5.2. 6” length of plastic tubing is to be used for the nail, lag screws for the blade, fully-threaded screws for the distal interlocking screw.
   5.3. Using a marker, draw the orientation of all components of the TFN on the bone. This will be the template for hardware insertion and TFN design.

**Discussion Point**
Q. What is the angle between the femoral neck and the shaft? Measure with the goniometer.
A. It is approximately 135 degrees.

5.4. Using the template drawn on the bone, mark blade and distal screw locations on the nail (tubing). Note that the blade hole is at an angle, roughly corresponding to the angle between the femoral neck and shaft.
5.5. Measure screws and select appropriate maximum drill diameter for slip fit.
   5.5.1. Lag screw (blade): This is a #10 screw, and a 7/32” drill hole is recommended.
   5.5.2. Distal screw: This is a #6-#8 screw, and a 1/8 drill hole is recommended.
5.6. Drill holes to diameter determined in Step 5.5 at locations determined in Step 5.4.

**Discussion Point**
Q. When the nail is inserted into the bone, it will likely spin axially. How will this affect insertion of the blade? How will you fix this problem?
A. When the nail spins during insertion, there will be no way to tell the direction of the blade hole (or distal screw hole, if so desired). This will make inserting the screws a problem. One solution to this is to make a slotted notch at the proximal end of the nail (with oscillating saw). The orientation of the notch can be in-line with the blade hole axis. A flathead screwdriver can then be used to adjust the orientation of the nail after it has been inserted so that the blade hole is pointed in the desired direction.

6. Fracture Fixation
   6.1. Nail drilling & reaming
      6.1.1. See Model #3 for proposed location for nail.
      6.1.2. Drill hole for nail using sequentially larger 6” drill bits up to 3/8”.
      6.1.3. Flexible-drive 3/8” reamer should be used to clear out intramedullary canal.
   6.2. Insert nail and adjust orientation so blade hole is pointed in desired direction.
   6.3. Install blade at locations marked in Steps 5.3-4.
   6.4. Install distal interlocking screw at location marked in Step 5.4.
   6.5. Rubber bands are provided in hardware kit to use as depth stops on drill.

7. Self-assessment
   7.1. *(Slide #4)* Select a trochanteric fracture type. Mark fracture line, and cut with oscillating saw or small hacksaw. Make sure not to cut the TFN “blade.”
7.2. After making a fracture across the entire bone cross section (but not the “blade”), check whether your TFN is functional by seeing if the medial fracture fragment can slide medial/lateral against the greater trochanter.

Discussion Point
Q. “Blind” placement of screws, such as you were doing in your TFN design, are extremely difficult operations to perform. How many attempts did you have to make with the k-wires before you found the screw holes? (Would you want to do this in a real patient?) How would you design a system to allow you to know the screw hole locations exactly?

A. (Slide #7) Surgeons want to place the blade and any interlocking screws through the nail on the first attempt, to avoid tissue damage to the patient from multiple stabs. They have various tools at their disposal to accomplish this. To do this, they use a jig sets the proper location and angle for screw insertion.

8. Break-Down
8.1. Students may keep the proximal femur models with the “TFNs.”