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Indications

Two-part fractures of the humerus
Three-part fractures of the humerus
Midshaft Diaphyseal Fracture(s)
Segmental Humerus Fracture(s)

Nota Bene: This technique description herein is made available to the healthcare professional to illustrate the author's suggested treatment for the uncomplicated procedure. In the final analysis, the preferred treatment is that which addresses the needs of the patient.
Uncover an easier and more advanced nailing system

The TRIGEN Humeral Nail provides new possibilities for the treatment of proximal humeral fractures and humeral shaft fractures. With multiplanar screws that are threaded into the nail to inhibit proximal screw back-out, and effective, simple instrumentation that helps protect soft tissues, the TRIGEN System now offers an effective intramedullary nail for humeral fracture management.
The TRIGEN Humeral Nailing System product offering includes a 16cm Proximal Straight Nail, a 16cm Proximal Bent Nail, and a full line of Long Bent Nails. Nails with a proximal bend are best suited for simple two-part fractures of the proximal humerus involving the surgical neck of the humerus and proximal third humeral fractures without comminution. In these scenarios, the Herzog curve facilitates an easier entry portal attainment and nail insertion with an incision just medial to the rotator cuff insertion.

The Long Bent Humeral Nail is primarily indicated for humeral shaft fractures which are inherently not prone to varus malposition. The lateral portal design allows insertion just medial to the rotator cuff insertion and facilitates easier portal attainment and nail insertion.

The 16cm Proximal Straight Humeral Nail offers the option of a medialized entry site. If the greater tuberosity is fractured or compromised, a straight centralized starting point avoids fracture extension from the tuberosity fracture into the entry portal and resultant loss of nail stability. The entry portal for the straight nail is slightly more difficult to attain than the curved nail entry portal.

Design Rationale

The TRIGEN Humeral Nailing System product offering includes a 16cm Proximal Straight Nail, a 16cm Proximal Bent Nail, and a full line of Long Bent Nails. Nails with a proximal bend are best suited for simple two-part fractures of the proximal humerus involving the surgical neck of the humerus and proximal third humeral fractures without comminution. In these scenarios, the Herzog curve facilitates an easier entry portal attainment and nail insertion with an incision just medial to the rotator cuff insertion.

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**PROXIMAL STRAIGHT HUMERAL NAIL**

- **TRIGEN 8/7mm X 16cm Proximal Straight Humeral Nail** offers an alternate choice in treating different fracture patterns.

**LONG BENT HUMERAL NAIL**

- **Four multiplanar proximal locks improve fracture stability.**

** locking holes**

- **5.0mm Cancellous Proximal Locking Screws; 24mm – 64mm lengths, 2mm increments**

**25° 25°**

- **4.0mm Cortical Distal Locking Screws; 20mm – 40mm lengths, 2mm increments**

Proximal locking holes have innovative threaded design. Screws thread into the nail to help prevent screw back-out.
Design Features

Nail Specifications

TRIGEN
Humeral Nail 8/7mm X 16cm
Proximal Bent Humeral Nail

TRIGEN
Humeral Nail 8/7mm X 16cm
Proximal Straight Humeral Nail

TRIGEN
Long Bent Humeral Nail 8/7mm, 9/7.5mm, 10/8.5mm Diameter;
18cm – 28cm Lengths, by 2cm increments

Trapezoidal 12mm X 10.5mm Cross section
Proximal Taper
First Diameter Measurement: 8mm
Second Diameter Measurement: 7mm

Trapezoidal 12mm X 10.5mm Cross section
Proximal Taper
First Diameter Measurement: 8mm, 9mm, or 10mm
Second Diameter Measurement: 7mm, 7.5mm, or 8.5mm

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Proximal Bent Humeral Nail

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Patient Positioning

Supine Position
Position the patient supine with 3 liter bags of saline between scapulas. Lateralize the patient on the fluoroimage table so that the humerus may be extended posteriorly (Figure 1).

The C-arm may be positioned either superior to the shoulder or opposite the shoulder if the C-arm modus is large enough.

Alternative Position
Position the patient in a slight “beach-chair” position. The arm of the semi-recumbent patient is left to hang near the trunk thus its weight helps reposition the humeral head anterior to the acromion. The C-arm is placed above the head of the table at 30° extending distally over the shoulder. This will allow an anteroposterior view of the humerus. The arm should be placed in reverse pushing position to clear the entry point, anatomically located at the superior margin of the articular surface just medial to the greater tuberosity.

Once the correct positioning and imaging are assured, the shoulder and arm are prepped and draped.
Incision

The incision approach that is recommended and most often used for antegrade humeral nailing is the lateral deltid splitting incision. For complete fractures or nonunions, a traditional deltopectoral approach may be used.

A 2-3cm incision is made from the edge of the acromion to the edge of the head of humerus, anterolateral to the tip of the acromion. The deltid is divided down to the sub-deltoid bursa. The deltid muscle is then retracted. Visualize the rotator cuff insertion into the greater tuberosity. The biceps tendon is palpated anteriorly. The rotator cuff supraspinatus tendon is incised 15-20mm in line with its fibers, exposing the humeral head. Insert suture into the rotator cuff interval to retract the rotator cuff and facilitate its repair after insertion of the nail (Figure 2).

Lateral Portal (Bent Humeral Nail)
Entry portal is made just medial to the tendon insertion and centered midway between the biceps groove anteriorly and the posterior humeral head (Figure 3).

Central Portal (Straight Proximal Nail)
Entry portal is made at the apex of the humeral head and centered midway between the biceps groove anteriorly and the posterior humeral head (Figure 3).
Entry Tool and Guide Pin Placement

The rotator cuff is divided to expose the superior portion of the humeral head. The Entry Cuff Guard protective device should be used to retract the soft tissue of the rotator cuff for visualization of the bone. The Cuff Guard provides a visual working channel, while protecting the rotator cuff and soft tissue during the procedure.

Attach the 3.2mm Tip Threaded Guide Pin or Trocar to the Mini Connector with Handle. Place through the Cuff Guard into the superior margin of the humeral head just medial to the greater tuberosity, avoiding the rotator cuff insertion (Figure 4).

Verify position on the C-arm to confirm guide pin placement is aligned in the medullary canal by oblique pictures at 45° with internal and external rotation of the shoulder.
Prepare Proximal Section

Insert the Straight Entry Reamer over the 3.2mm Tip Threaded Guide Pin or the Trocar through the Cuff Guard to prepare the humerus for the proximal section of the nail. Ream until the cutting teeth are just below the articular surface of the humeral head (Figure 5). The depth indicator on the reamer should be level with the top of the Cuff Guard.

The proximal humerus can also be prepared by using the Humeral Broach. The broaching method utilizes the noncylindrical shape of the proximal body of the nail to help rotationally stabilize the nail during insertion of the locking screws.

Use the Humeral Nail Guide Bolt to attach the Nail Drill Guide to the Broach (Figure 6). The Broach and the Nail Drill Guide are keyed to ensure proper orientation of the Broach on the Nail Drill Guide. Tighten down the Nail Guide Bolt using the Guide Bolt Wrench. The Impactor is then attached to the Nail Guide Bolt.

The awl-tip on the Humeral Broach can be used to perforate the cortical bone of the articular surface. The Broach should be inserted over the 3.2mm Tip Threaded Guide Pin or the Trocar. It may be necessary to use the Small Hammer to gently advance and retract the Broach to prepare the canal of the proximal humerus to accept the nail.

Alternatively, the Cannulated Awl can be used with the Straight Ratcheting Driver in place of the Broach.
Fracture Reduction

After removing the Straight Entry Reamer and 3.2mm Tip Threaded Guide Pin or Trocar, insert the Straight Reducer attached to the Straight Ratcheting Driver with the slot oriented toward the lateral cortex and reduce the fracture. Place the tip of the finger off the medial cortex to help reduce the fracture (Figure 7).

To maintain reduction, disconnect the Straight Ratcheting Driver from the Straight Reducer and introduce the 2.0mm Graduated Ball Tip Guide Rod through the Straight Reducer. Then reattach the Straight Ratcheting Driver to the Straight Reducer (Figure 8). Center the Guide Rod 1-2cm proximal to the olecranon fossa in the distal end of the humerus. Once the Guide Rod is in place, carefully remove the Straight Reducer, using the Obturator as needed to ensure the Guide Rod stays in place (Figure 9).
Measuring Implant Length
To measure the length of the implant needed, ensure that the distal tip of the 2.0mm Graduated Ball Tip Guide Rod is located at the desired position of the distal tip of the nail. Slide the Ruler over the proximal end of the 2.0mm Graduated Ball Tip Guide Rod and advance the open end of the Ruler to where the proximal portion of the implant will be seated, just below the articular surface of the proximal humerus. Read the nail length from the calibrations exposed at the other end of the Ruler (Figure 10).

The 2.0mm Graduated Ball Tip Guide Rod has graduated markings and can be used to determine required implant length. The Straight Reducer can also be used to determine implant length, by using the markings on the reducer shaft. Both options are used to directly measure to the articular surface, taking care to ensure the nail will be slightly countersunk.

Additional Limited Reaming
(Necessary for Proximal Nails Longer than 8mm X 16cm)
After the nail length has been determined, additional limited reaming can be performed to avoid nail incarceration and distraction at the fracture site during insertion of the nail. Choose a Flex Reamer and insert it over the 2.0mm Graduated Ball Tip Guide Rod. Be careful not to "push" the guide rod distally during reaming. Never insert a nail that has a larger diameter than the last reamer used (Figure 11).

It is recommended that templating is done for all cases to estimate the size of the implant needed. The diameter of the last reamer used will help determine the diameter of the implant needed. Keep in mind that all of the nail sizes taper, and the canal should be reamed to 1mm over the implant diameter.
Surgical Technique

Nail Drill Guide Assembly

Once the implant selection is complete, use the Humeral Nail Guide Bolt to attach the Nail Drill Guide to the nail. The nail and Nail Drill Guide are keyed to ensure proper orientation of the nail on the Nail Drill Guide (Figure 12). Note: The metal threads on the proximal locking holes should always be lateral. Tighten the Humeral Nail Guide Bolt using the Guide Bolt Wrench. The Impactor is then attached to the Humeral Nail Guide Bolt.

To complete the assembly, attach the Proximal Drop to the lateral arm of the Nail Drill Guide (Figure 13). Tighten the Proximal Drop to the Guide using the knurled knob. The Proximal Drop should be used to target the proximal screws on all Humeral Nails, and the distal screws on the 16cm Proximal Nails. Distal locking screws for the 18cm or longer Humeral Nails should be targeted using a freehand technique.
Nail Insertion
At this point the nail is ready to be inserted. Care should be taken to insert the nail with the correct amount of retroversion and depth in order to maximize locking screw fixation while avoiding critical soft tissues such as the biceps tendon, axillary and radial nerves.

Insert the nail attached to the Nail Drill Guide Assembly over the 2.0mm Graduated Ball Tip Guide Rod and through the Cuff Guard with the lateral arm of the drill guide oriented with approximately 30-35° of retroversion ([Figure 14]). Adjustments to this version can be made so that the anterior arm of the drill guide is in line with the lesser tuberosity, avoiding alignment with the bicipital groove. Proper depth is achieved when the lateral ledge on the drill guide is above the lateral cortex and the nail is seated just below the articular surface ([Figure 15]).

Remove the Guide Rod from the top of the Nail Drill Guide. Confirm that the fracture is compacted and not distracted ([Figure 16]).
Final Version Adjustment

Final and rigid version adjustment to the nail can be performed prior to inserting the proximal locking screws by attaching the Anterior Stylus to the anterior arm of the Nail Drill Guide.

Insert the Trocar through the Anterior Stylus and position the nail so that the Trocar can be inserted into the lesser tuberosity at the location of the anterior locking hole. Leave the Trocar in place to maintain fracture reduction and rotational stability during the insertion of the proximal lateral screws (Figure 17a).

This step ensures that the proximal anterior and proximal anterolateral locking screws will not be inserted into the bicipital groove, potentially injuring the biceps tendon (Figure 17b).
Proximal Locking Screws

**Caution:** Do not countersink the nail such that proximal locking screws are below the level of the humeral head to avoid damage to the axillary nerve.

In order to avoid impingement of the biceps tendon, it is a good idea to start with the proximal anterolateral locking screw. Place the 3.2mm Silver Inner Drill Sleeve into the Gold Outer Sleeve. Insert the sleeve unit into the Proximal Drop (Figure 18). The Trocar can be inserted into the sleeve unit to determine the exact location for the insertion of the locking screw. If the Trocar tip indicates the proximal anterolateral screw is in line with the bicipital groove, reorient the nail to avoid impingement. Once proper alignment has been achieved, make a stab incision and push the sleeve assembly down to the bone. Use the Trocar to dimple the cortex. Remove the Trocar from the sleeve unit and drill through the near cortex, stopping at the articular surface of the far cortex using the 3.2mm Long Graduated Two-Flute Drill (Figure 19). Take the length measurement from the calibrations on the drill (Figure 20) or the Screw Depth Gauge (Figure 21). The 3.2mm Silver Inner Drill Sleeve must be removed from the Gold Outer Sleeve in order to use the Screw Depth Gauge.
Proximal Locking Screws (Cont.)

Remove the 3.2mm Silver Inner Drill Sleeve and insert the 3.5mm Hex Driver with the appropriate length 5.0mm Cancellous Screw attached (Figure 22). The head of the screw should be nearly seated when the laser marked ring on the 3.5mm Hex Driver is even with the Gold Outer Sleeve. Final seating of the screw should always be under manual control using the Straight Ratcheting Driver to avoid over insertion of the screw in Osteoporotic bone (Figure 23).

Insert the remaining two proximal locking screws.
Proximal Locking Screws (Cont.)

To target the proximal anterior locking hole, remove the Anterior Stylus and attach the Proximal Drop on the anterior arm of the Nail Drill Guide. **Caution: Locate biceps tendon prior to beginning placement of the anterior screw.**

Insert the 3.2mm Silver Inner Drill Sleeve into the Gold Outer Sleeve. Insert the sleeve assembly into the hole marked “Anterior” on the Proximal Drop (Figure 24).

Follow the same procedure described previously to drill, measure, and insert the Anterior and Posterior Proximal Screws, (*Figures 24 - 28*).
Distal Locking Screws (4.0 mm Screws)

**Note:** The Proximal Drop only targets the distal holes for the 16cm nails. Nails longer than 16cm will be targeted using the freehand technique.

With the Proximal Drop connected to the lateral arm of the Nail Drill Guide, place the 3.2mm Silver Inner Drill Sleeve into the Gold Outer Sleeve. Insert the sleeve unit into the targeting hole in the Proximal Drop which corresponds to the superior M/L distal locking hole in the nail. While applying compression from the elbow to reduce shaft fractures if necessary, make a stab incision and push the sleeve assembly down to the bone. The Trocar may be used to dimple the cortex. Drill through both cortices using the 3.2mm Graduated Two-Flute Drill (Figure 29). A length measurement can be taken from the calibrations on the drill (Figure 30) against the 3.2mm Silver Inner Drill Sleeve, or the Screw Length Gauge can be used through the Gold Outer Sleeve to measure for distal locking screws (Figure 31).

Once the appropriate length 4.0mm Self-Tapping Cortical Screw is selected, it is attached to the 3.5mm Hex Driver. The screw is inserted through the Gold Outer Sleeve using the 3.5mm Hex Driver (Figure 32). The head of the screw should be nearly seated when the laser-marked ring on the Hex Driver is even with the Gold Outer Sleeve. Final tightening of the screw should always be performed manually using the Straight Ratcheting Driver (Figure 33). Repeat this process for the inferior distal screw.
Distal Locking Screws (Cont.)

**Freehand Locking**

Distal locks on all nails 18cm and longer should be done using freehand technique. The Screw Length Sleeve can be used with the 3.2mm Short Graduated Two-Flute Drill to drill for the A/P distal locks. Length measurements can be made by using the graduations on the drill against the Screw Length Sleeve. The Screw Length Gauge could also be used to determine the appropriate screw length. Once the appropriate length 4.0mm Self-Tapping Cortical Screw is selected, it is attached to the 3.5mm Hex Driver. The screw is inserted through the Gold Outer Sleeve using the 3.5mm Hex Driver. Final tightening of the screw should always be performed manually using the Straight Ratcheting Driver. Repeat this process for the inferior distal screw *(Figure 34).*

**Closure**

Close the wound in layers, use nonresorbable sutures in the rotator cuff repair. Close the remainder of the incision in a standard fashion.

**Nail Removal**

The Screw Head Trephine, the Proximal Nail Trephine and the Extractor are included in the instrument set to facilitate nail removal.
TRIGEN Humeral Nail Cap
(Not Shown)
Cat. No.  7176-0000

TRIGEN Proximal Straight Humeral Nail
Cat. No.  Size  Length
7176-0816  8/7mm  16cm

TRIGEN Proximal Bent Humeral Nail
Cat. No.  Size  Length
7177-0816  8/7mm  16cm

TRIGEN Long Bent Humeral Nail
Cat. No.  Size  Length  Cat. No.  Size  Length
7177-0818  8/7mm  18cm  7177-0924  9/7.5mm  24cm
7177-0820  8/7mm  20cm  7177-0926  9/7.5mm  26cm
7177-0822  8/7mm  22cm  7177-0928  9/7.5mm  28cm
7177-0824  8/7mm  24cm  7177-1018  10/8.5mm  18cm
7177-0826  8/7mm  26cm  7177-1020  10/8.5mm  20cm
7177-0828  8/7mm  28cm  7177-1022  10/8.5mm  22cm
7177-0918  9/7.5mm  18cm  7177-1024  10/8.5mm  24cm
7177-0920  9/7.5mm  20cm  7177-1026  10/8.5mm  26cm
7177-0922  9/7.5mm  22cm  7177-1028  10/8.5mm  28cm

5.0mm Self-Tapping Cancellous Screw
Cat. No.  Length  Cat. No.  Length
7175-5024  24mm  7175-5046  46mm
7175-5026  26mm  7175-5048  48mm
7175-5028  28mm  7175-5050  50mm
7175-5030  30mm  7175-5052  52mm
7175-5032  32mm  7175-5054  54mm
7175-5034  34mm  7175-5056  56mm
7175-5036  36mm  7175-5058  58mm
7175-5038  38mm  7175-5060  60mm
7175-5040  40mm  7175-5062  62mm
7175-5042  42mm  7175-5064  64mm
7175-5044  44mm

4.0mm Self-Tapping Cortical Screw
Cat. No.  Length  Cat. No.  Length
7175-4020  20mm  7175-4032  32mm
7175-4022  22mm  7175-4034  34mm
7175-4024  24mm  7175-4036  36mm
7175-4026  26mm  7175-4038  38mm
7175-4028  28mm  7175-4040  40mm
7175-4030  30mm
Entry Cuff Guard
Cat. No. 7175-1100

Disposable Cuff Guard
(Not Shown)
Cat. No. 7175-1101

3.2mm Tip Threaded Guide Pin
Cat. No. 7175-1147

Trocar
Cat. No. 7175-1136

Mini Connector with Handle
Cat. No. 7175-1137

Straight Entry Reamer
Cat. No. 7175-1103

Humeral Broach
Cat. No. 7175-1104

Small Hammer
Cat. No. 7175-1135

Humeral Nail Guide Bolt
Cat. No. 7175-1108

Nail Drill Guide
Cat. No. 7175-1129

Guide Bolt Wrench
Cat. No. 7175-1134
Straight Reducer
Cat. No. 7175-1105  OD=7.1mm  ID=4.2mm

Straight Ratcheting Driver
Cat. No. 7175-1141

3.2mm Silver Inner Drill Sleeve
Cat. No. 7175-1116

Flex Reamers

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Impactor
Cat. No. 7175-1133

Obturator
Cat. No. 7175-1145

2.0mm x 600 mm Graduated Ball Tip Guide Rod
Cat. No. 7175-1146

Ruler
Cat. No. 7175-1126

Proximal Drop
Cat. No. 7175-1131

Anterior Stylus
Cat. No. 7175-1130

3.2mm Silver Inner Drill Sleeve
Cat. No. 7175-1116
Mini Connector with Handle  
Cat. No. 7175-1137

Gold Outer Sleeve  
Cat. No. 7175-1128

Humeral Ruler  
Cat. No. 7175-1126

3.2mm Graduated Two-Flute Drill  
Description | Cat. No.  
| --- | ---  
| Short | 7175-1148  
| Long | 7175-1149

Screw Depth Gauge  
Cat. No. 7175-1139

3.5mm Hex Driver  
Cat. No. 7175-1140

AO Mini Connector  
Cat. No. 7175-1153

Mini Connector  
Cat. No. 7163-1186

Trinkle Connector  
Cat. No. 7163-1187

Screw Head Trephine  
Cat. No. 7175-1144

Proximal Nail Trephine  
Cat. No. 7175-1143
Cannulated Awl  
Cat. No. 7175-1102

Extractor  
Cat. No. 7175-1142

Screw Length Sleeve  
Cat. No. 11-0238

TRIGEN Humeral Nail Instrument Set  
(Not Shown)  
Cat. No. 7175-1150

Top Instrument Tray  
(Not Shown)  
Cat. No. 7175-1151

Bottom Instrument Tray  
(Not Shown)  
Cat. No. 7175-1152

Case  
(Not Shown)  
Cat. No. 7112-9400

Case Lid  
(Not Shown)  
Cat. No. 7112-9402

Reamer Cassette  
Cat. No. 7175-1154
Notes