





The Titanium Flexible Humeral Nail

A flexible nail designed for optimum off-axis insertion into the medullary canal







Tension block

Nail is transformed from flexible to stiff by inserting the tension screw



Sigmoid geometry Provides approximately 5° of angulation between interconnected segments

Central wire Part of the stiffening mechanism of the nail

Nail tip

- Beveled for easy passage down the canal
- Two transverse locking holes
- Four peripheral wire exit holes

Distance from nail tip to distal locking holes:

	Antegrade	Retrograde
AP	8.0 mm	14.0 mm
LM	14.0 mm	8.0 mm

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Anatomy and the Flexible Humeral Nail Concept

The muscles of the rotator cuff hold the head of the humerus in close apposition to the glenoid cavity during movements of the upper limb. The rotator cuff is composed of four muscles and tendon attachments that insert onto the greater and lesser tuberosities:

- Subscapularis
- Supraspinatus
- Infraspinatus
- Teres minor (not shown)

The Flexible Humeral Nail has been designed to avoid these critical structures.

A flexible nail for optimum insertion

- Avoids the rotator cuff during antegrade insertion
- Flexibility facilitates retrograde insertion

A stiffened nail creates a rigid internal splint

- Allows longitudinal, angular, and rotational fracture control
- Includes AP and LM locking options

Indications

The Titanium Flexible Humeral Nail is intended for the following indications:

Acute humeral shaft fractures, including certain pre- and postisthmic fractures (including, but not limited to, transverse, short oblique, long oblique, butterfly, and segmental fractures of all grades of comminution)



Blue areas indicate muscle attachments; yellow indicates the axillary nerve.

Recommended Approaches

Antegrade nailing

Mid-shaft to distal fractures and humeri with narrow distal canals

Retrograde nailing

Mid-shaft to proximal fractures with adequate distal canals

Case Examples

Antegrade



Preoperative

A midshaft humeral fracture in a 36-yearold polytrauma patient, victim of a motor vehicle accident.



Immediate postoperative

A 7.5 mm Titanium Flexible Humeral Nail was inserted antegrade to stabilize the fracture.



Preoperative

An open oblique, comminuted fracture of the proximal humerus, with extension into the midshaft. The 18-year-old patient was the victim of a gunshot wound. Retrograde



3 weeks postoperative

A 7.5 mm Titanium Flexible Humeral Nail was inserted retrograde to stabilize the proximal fracture.



4 months postoperative

Follow-up shows radiographic union.

Patient Positioning

Determine patient position based on the patient's physical condition, pattern and location of injury, surgical approach, and surgeon's preference. The patient may be placed in the supine, prone, or in the semi-reclined supine position (beach chair).

Antegrade nailing in supine position

Affected arm can be placed in neutral position or on a radiolucent arm board with a bolster under the affected shoulder.

Antegrade or retrograde nailing in the beach chair (semi-reclined supine) position:

Place a bolster under the shoulder, or position the arm and shoulder beyond the edge of the table. Turn the patient's head away from the injured side.

Position the image intensifier on the side opposite the fracture. Ensure that the fracture can be reduced before proceeding, and that appropriate images can be obtained.

Note: The optimal position allows imaging of AP and lateral views of the proximal humerus without moving the patient or arm. This can be achieved by positioning the patient in a 45° semi-supine/semi-lateral position. This allows the image intensifier to be positioned from the opposite side of the table.

Retrograde nailing in supine position

Place the affected arm beyond the edge of the table. Hold the forearm in flexion and across the chest, or suspend the forearm in flexion using skeletal traction with an olecranon traction pin.

Place the image intensifier parallel to the floor and approach the injured humerus from the patient's head or contralateral side. Bolster the shoulder, if needed, to ensure visualization of the entire humerus. Ensure that the fracture can be reduced before proceeding.



Alternatively, place the patient in the lateral decubitus position.

Antegrade Nail Insertion

Preoperative nail selection



(magnification factor 1.05) If measured nail length is 240 mm 240/1.05 = 228 Choose a 225 mm nail.

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Select nail length

Place the Preoperative Planning Template on the X-ray of the reduced, affected humerus or the contralateral intact bone.

Approximate the location of the insertion point and the nail tip. Determine the appropriate nail length. The straight nail should be centered in the AP view. The proximal end of the 15 mm extension piece (dashed lines on template) will be flush with the cortical margin.

Caution: Nail length is determined differently for antegrade and retrograde techniques. See pages 24–26 for instructions regarding retrograde nail length.

Select nail diameter

Place the Preoperative Planning Template on the lateral X-ray of the uninjured humerus to determine nail diameter preoperatively.

Measure the diameter at the narrowest part of the medullary canal that will contain the nail.

Choose the appropriate diameter nail.



Intraoperative Nail Size Confirmation

Confirm nail length

Method 1: Using calibrated reaming rod

After opening the medullary canal, insert the 2.5 mm Calibrated Reaming Rod and note the measured canal length. Select a nail that is one size shorter than this measurement, as the labeled nail length does not include the removable 15 mm extension piece. Leave this extension piece on, to extend the nail 15 mm to the cortical margin.

Use caution not to overinsert the Reaming Rod as the distal canal may not accept the nail tip.

Note: Overinsertion of the Reaming Rod will result in selection of a longer length nail than desired.

Example: The 2.5 mm Calibrated Reaming Rod, when inserted, measures a canal length of 240 mm. Select a 225 mm nail. The 15 mm extension piece will extend the nail to the appropriate length.



Method 2: Using image intensifier

Position the image intensifier for an AP view of the distal humerus, with the beam perpendicular to the shaft. When measuring the fractured humerus, apply gentle traction to restore length.

Hold the Radiographic Ruler with a Kocher or similar forceps, and position it adjacent (and parallel to) the humerus. Under image intensification, move the tapered end (which corresponds to the nail tip) to the desired level in the distal humerus.

Mark the skin at the tapered end of the ruler.

Note: The hole closest to the tapered end of the ruler tip corresponds to the AP locking hole in antegrade nailing.



Place ruler along lateral aspect.

Method 2 (continued)

Move the image intensifier to the proximal humerus.

Take an AP image of the proximal humerus, centering the beam at the nail insertion site. Verify fracture reduction and ruler tip position.

Reading directly from the ruler image, select the length at or just distal to the proximal margin of the planned insertion site.

Caution: When choosing nail length, select one size shorter than the measured canal length, as the nail length does not include the 15 mm extension (antegrade example, if the canal measures 240 mm with the radiographic ruler, select a 225 mm nail).



Read nail length.

Confirm nail diameter

To confirm nail diameter, position the image intensifier for a lateral view of the distal humerus.

With a long forceps, place the ruler against the arm so the diameter gauge is centered over the narrowest part of the medullary canal.

The inner dimension of the bracket, as indicated on the gauge, corresponds to the nail shaft diameter. When the medullary canal can be visualized through the gauge, that diameter nail can be inserted.





Instruments to Open the Proximal Humerus



Flexible Medullary Reamer, 8.0 mm* 359.110

*Additionally available

Opening the Proximal Humerus

Make incision

Approach the greater tuberosity through a longitudinal incision in the deltoid fibers, just distal to the rotator cuff. Use caution, for the axillary nerve is approximately 5 cm distal from the tip of the acromion (this distance may be less in some patients).

2

Identify insertion point

Place the tip of the Medium Awl at the planned entry point, centered in the greater tuberosity (distal and lateral to the rotator cuff).

Confirming position with the image intensifier, use the awl to open the medullary canal.

Caution: The insertion site will be approximately 11 mm in diameter. The awl tip should be inserted approximately 1 cm distal to the rotator cuff so that the enlarged hole does not invade the cuff fibers.

Note: In most patients (with soft-to-normal bone), the awl will develop the necessary path for nail passage without additional steps. In younger patients with dense bone it may be necessary to further develop the entry hole.





Use the awl to open medullary canal.



Ensure the awl is centered in the canal. Do not misdirect the awl laterally.

Opening the Proximal Humerus (continued)

Confirm size and shape of entry hole

3 Insert Nail Trial

Insert the Nail Trial to confirm the size and shape of the entry hole. The entry hole should approximate the geometry of the nail head, to facilitate hand insertion of the nail.

To confirm that the entry hole will accommodate the nail, slide the Nail Trial into the hole until the Trial is flush with the cortex. If it fits, proceed with instrument assembly and nail insertion.

Note: For most patients, the Nail Trial is an excellent tool to:

- Confirm size and shape of the entry hole after awl passage
- Finish preparing the shape of the entry hole
- Round out the entry hole and possibly eliminate the need for drilling near the shoulder. (However, the distal humerus may be reamed in patients with narrow distal canals.)

If the Nail Trial does not fit easily into the prepared hole, enlarge the entry hole using the 10.5 mm Flexible Drill Bit [359.079] over the 2.5 mm Calibrated Reaming Rod [359.083].

Insert 2.5 mm Calibrated Reaming Rod

Insert the 2.5 mm Calibrated Reaming Rod into the canal, using the Universal Chuck with T-Handle. Monitor insertion of the rod with image intensification to ensure proper placement.

Note: The nail is not cannulated. The reaming rod must be removed prior to nail insertion.





Insert the Reaming Rod using the Universal Chuck with T-Handle.

Confirm size and shape of entry hole (continued)

Insert 10.5 mm Flexible Drill Bit over rod

Using the Compact Air Drive and Large Quick Coupling, pass the 10.5 mm Flexible Drill Bit over the reaming rod.

Enlarge entry site

Enlarge the entry site as required, with the 10.5 mm Flexible Drill Bit. It is only necessary to pass this drill bit approximately to, or just below, the level of the surgical neck.

Note: The funnel shape of the distal humerus may necessitate reaming to accommodate the nail tip.

Flexible Medullary Reamers [359.106–359.115], available from 6.0 mm to 10.5 mm, may be passed over the Reaming Rod to further prepare the canal for nail insertion. In young patients or patients with especially dense bone or narrow medullary canals, it may be necessary to ream up to the nail shaft diameter plus 0.5 mm.

Note: The reamers for the Flexible Humeral Nail have short head lengths for turning corners. (It is not recommended to use any other small-diameter reamer with a long head.) The flexible reamers are operated on high speed/low torque drives, rather than a reamer reduction drive. Use the Large Quick Coupling [511.76].

When drilling and reaming are complete, the 2.5 mm Calibrated Reaming Rod may be used for intraoperative length verification (see page 8).

Reinsert Nail Trial

Reinsert the Nail Trial. If the Nail Trial inserts fully, the entry site is ready for nail insertion.



Use flexible drill bits and reamers to prepare for nail passage. (Do not operate these drill bits and reamers in reverse.)



Instruments for Nail Insertion



Additionally available

Small F-Tool	359.209
Hammer	399.41

Nail Insertion

Assemble the insertion instruments

Cut peripheral wires

Prior to assembling the insertion instrumentation for antegrade implantation, cut the peripheral wires flush with the 15 mm extension piece, using the Percutaneous Wire Cutter [359.090]. For a detailed description of the Percutaneous Wire Cutter, see page 44, End Cap Placement.

Caution: Do not remove the peripheral wires from the nail. They are part of the nail structure.



Cut wires.

Assemble Connecting Screw through handle

Slide the Connecting Screw [359.054] through the Insertion Handle [359.052].

Tighten Connecting Screw

Pass the Connecting Screw through the 15 mm extension piece of the nail and thread it into the proximal segment, using the Ratchet Wrench [321.20]. The concave aspect of the nail bend will be oriented toward the Insertion Handle. Tighten securely.



Insert Connecting Screw through handle.



Tighten Connecting Screw to nail with Ratchet Wrench.

Attach Insertion Cap

If hammering is desired, couple the Insertion Cap [359.070] onto the Connecting Screw and slide the collar toward the nail until it locks.



Attach Slide Hammer

Attach the Slide Hammer [359.036] to the shaft of the Insertion Cap. (Do not directly strike the Connecting Screw.)



Attach Insertion Cap to Connecting Screw.



Attach Slide Hammer to shaft of Insertion Cap.

Nail Insertion (continued)

Insert the nail

Insert nail into canal

Manually insert the flexible nail into the medullary canal. The nail should slide easily into the canal by hand.

2

Seat nail

Verify fracture reduction and pass the nail across the fracture using manual pressure, or slight taps of the Slide Hammer [359.036] as needed. Finish inserting the nail by seating the top of the nail inside the entry portal.

Heavy blows with the Slide Hammer are not necessary. Should the nail jam at the entry site or in the canal, the slide hammer may be used to back out the nail. If heavy force is needed to seat the nail head, the entry hole should be enlarged, as previously outlined, using the flexible drill bits.

Monitor nail passage and fracture reduction under image intensification.

Note: The nail's flexibility allows it to be inserted in an optimum off-axis insertion site, yet it is stiff enough to be used as a reduction aid when passing the fracture site (use the Insertion Handle as a joystick.) In addition, the Small *F*-tool [359.209] may be used to help with fracture reduction.

³ Verify nail position

Final nail position can be verified by placing a 3.2 mm Drill Bit through the small drill hole in the Insertion Handle. The check hole for antegrade insertion is furthest away from the nail tip. This hole marks the junction between the Insertion Handle and the 15 mm extension piece.

Caution: Antegrade insertion may distract the fracture. Do not leave a fracture gap after reduction and nail passage. As precise apposition of fragments as possible may help to prevent delayed union or non-union.



Note: Flex the nail by bending the insertion bandle toward the nail tip. This may facilitate insertion by relieving stress on the entry site as the nail slides down the canal.



Verify nail position by placing a 3.2 mm Drill Bit through the small check hole farthest from the nail tip.

Implants and Instruments for Stiffening and Locking



Nail Stiffening and Locking

Stiffen the nail

Remove Insertion Cap

If the Insertion Cap was attached for insertion, remove it from the Connecting Screw. With the button depressed, slide the captivator of the Insertion Cap away from the Connecting Screw. Release the Insertion Cap.

Create incision

Create a stab incision below the purple hole marked "STIFF" on the insertion handle. The incision should be bluntly dissected to the cortex to avoid the axillary nerve.

Note: Always measure before drilling and inserting the Tension Screw.

Measure for 4.0 mm Tension Screw

Insert the Tension Screw Measuring Gauge through the insertion handle and to the bone. Ensure it is completely seated on the cortex. Note the tension screw measurement and remove the gauge.

Note: If the measurement is between two sizes, always choose the shorter length.







Insert the Tension Screw Measuring Gauge.

Insert trocar and protection sleeve

Insert the 11.0 mm/8.0 mm Protection Sleeve and 8.0 mm Trocar through the same hole, marked "STIFF".



Insert the 11.0 mm/8.0 mm Protection Sleeve and 8.0 mm Trocar.

Stiffen the nail (continued)

Insert drill sleeve with bell

Remove the trocar and insert the 4.0 mm Drill Sleeve with Bell into the 11.0 mm/8.0 mm Protection Sleeve.

Drill to stop

Drill with the 4.0 mm Drill Bit to the stop. Only the near cortex will be drilled, leaving the nail untouched.

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Remove drill bit and drill sleeve with bell

Remove the 4.0 mm Drill Bit and 4.0 mm Drill Sleeve with Bell, leaving the outer 11.0 mm/8.0 mm Protection Sleeve in place.

Insert 4.0 mm Tension Screw

Using the self-retaining 3.5 mm Hexagonal Screwdriver, slide the chosen 4.0 mm Titanium Tension Screw through the sleeve and into the drilled hole.

Holding the Insertion Handle with one hand, apply axial pressure on the screwdriver and turn the tension screw into the nail, through the tension block.

Note: As the screw is threaded into the nail, the resistance will increase. This is normal and will decrease to a steady level once the screw cone has cleared the nail. The color-coded ring on the self-retaining screwdriver will approximate proper screw placement, indicating the head has reached the near cortex. (Always check under image intensification.)



Insert 4.0 mm Drill Sleeve with Bell into Protection Sleeve.



Drill to the stop.



Insert 4.0 mm Tension Screw.

Note: Do not pull the Insertion Handle laterally while inserting the tension screw.

Nail Stiffening and Locking (continued)

Stiffen the nail (continued)

Seat 4.0 mm Tension Screw

Insert the tension screw until its head is seated on the near cortex and the cone has cleared the far side of the nail. Be careful not to split the far cortex; monitor screw placement with the image intensifier.

Note: The tension screw is not bicortical.

Should there be any difficulty stiffening, check:

- *Is the screw in the nail? Check the AP view under image intensification.*
- Is the tension screw aligned straight on the self-retaining screwdriver? Screw tip may be missing the tension block.
- *Is the Insertion Handle tightened to the nail? Retighten the Connecting Screw.*
- *Is the Insertion Handle rotated away from the drilled bole?*
- Is the tip of the screw through the near cortex?

Warning: Do not reuse tension screws. Repeated insertion of a tension screw may strip or otherwise damage the threads, affecting the stiffening mechanism in the nail. If the tension screw is removed, discard it and use a new one.

If a second tension screw is inserted and removed, the internal threads of the nail will also be deformed and the nail should be replaced with a new one.







Lock the nail head

Extend incision

Extend the existing stab incision under the blue hole marked "LOCK" in the insertion handle.



Insert trocar and protection sleeve

Pass the 11.0 mm/8.0 mm Protection Sleeve and 8.0 mm Trocar through this hole.



Remove trocar and insert drill sleeve

Remove the trocar and insert the 8.0 mm/3.2 mm Drill Sleeve (color-coded blue).

1 Drill both cortices

Drill through both cortices using the 3.2 mm Calibrated Drill Bit (color-coded blue). Stop after penetrating the far cortex. Confirm drill tip position with the image intensifier.

5

Measure for locking bolt

Press the drill sleeve firmly to the cortex and read the measurement on the calibrated drill bit at the top of the sleeve. This reading provides the correct locking screw or locking bolt length.



Locking screw or locking bolt length can be read directly from the 3.2 mm Calibrated Drill Bit.



Insert protection sleeve and trocar.



Remove trocar, then insert 8.0 mm/3.2 mm Drill Sleeve.



Drill.

Nail Stiffening and Locking (continued)

Lock the nail head (continued)

Measure for locking bolt (continued)

Alternatively, remove the drill bit and drill sleeve, leaving the protection sleeve in place. Measure the correct locking screw or locking bolt length using the measuring hook of the Locking Bolt Measuring Device. Insert the hook into the protection sleeve and through the bone and nail, engaging the far cortex. Make sure the protection sleeve is pressed firmly against the cortex. Read locking screw or locking bolt length directly at the back of the protection sleeve.

Remove drill bit and drill sleeve

Remove the drill bit and drill sleeve from the protection sleeve.

Insert locking bolt or locking screw

Insert the chosen 4.0 mm Titanium Locking Screw or 3.9 mm Titanium Locking Bolt using the self-retaining 3.5 mm Hexagonal Screwdriver.

Lock the nail tip

Reconfirm fracture reduction.

Note: Always use at least one transverse locking bolt through the non-instrumented end of the nail. To avoid the radial nerve, consider an AP locking bolt.

Orient the image intensifier for an AP view of the distal humerus.

Make a longitudinal incision over the distal locking hole.

Insert the 4.0 mm Titanium Locking Screw or 3.9 mm Titanium Locking Bolt using standard freehand technique. Locking options include AP, PA, and LM. Be cautious of potential damage to the radial nerve when locking distally from lateral to medial. There is potential for musculocutaneous nerve damage when locking distally from anterior to posterior.



Alternatively, measure with the measuring book of the Locking Bolt Measuring Device.



Insert 4.0 mm Titanium Locking Screw or 3.9 mm Titanium Locking Bolt.



Implant and Instrument for End Cap Placement



3.5 mm Hexagonal Screwdriver, self-retaining 314.271



End Cap Placement

Remove the instrumentation from the nail.

With the 15 mm extension piece in place on the nail, insert the Titanium End Cap [475.093] into the nail head using the selfretaining 3.5 mm Hexagonal Screwdriver.

Note: The 15 mm end cap will prevent migration of the 15 mm extension piece and simplify nail removal. In the event the extension piece is prominent or extending from the entry site, remove it and insert the 0 mm end cap [475.091].



Insert 15 mm end cap.



End cap inserted.

Retrograde Nail Insertion

Preoperative nail selection

Caution: The nail image on this template is actual size, i.e., not magnified. Determine the typical magnification factor at your institution and then adjust measurements accordingly. To do this, divide the measured length by the magnification factor, and choose the nearest nail length.

Example:

A typical humeral X-ray image is enlarged by 5% (magnification factor 1.05) If measured nail length is 270 mm 270/1.05 = 257 Choose a 255 mm nail





Select nail length

Place the Preoperative Planning Template on the X-ray of the reduced, affected humerus or the contralateral intact bone.

Approximate the location of the insertion point and the nail tip. The instrumented end of the nail (solid lines on template), not including the 15 mm extension piece, should be flush with the cortical margin when the nail outline is aligned with the humeral axis.

Caution: Nail length is determined differently for retrograde and antegrade techniques. See pages 6–9 for instructions regarding antegrade nail length.

Caution: When a retrograde approach is chosen to stabilize subcapital fractures, use as long a nail as possible.

Select nail diameter

To determine nail diameter preoperatively, place the Radiographic Ruler on the lateral X-ray of the uninjured humerus.

Measure the diameter at the narrowest part of the medullary canal that will contain the nail.

Choose the appropriate diameter nail.

Intraoperative Nail Size Confirmation

Confirm nail length

Method 1: Using calibrated reaming rod

After opening the medullary canal, fully insert the 2.5 mm Calibrated Reaming Rod into the canal and note the measured canal length.

Select a nail that is the same size as this measurement. The labeled nail length will correspond to the measured canal length.

Example: The 2.5 mm Calibrated Reaming Rod, when fully inserted, measures a canal length of 240 mm. Select a 240 mm nail. The 15 mm extension piece will be removed in the retrograde procedure, as labeled nail length does not include this piece.



Intraoperative Nail Size Confirmation (continued)

Method 2: Using image intensifier

Position the image intensifier for an AP view of the proximal humerus, with the beam perpendicular to the shaft. When measuring the fractured humerus, apply gentle traction to restore length.

Hold the Radiographic Ruler with a Kocher or similar forceps, and position it on top of (and parallel to) the humerus. Under image intensification, move the tapered end (which corresponds to the nail tip) to the desired level in the proximal humerus.

Mark the skin at the tapered end of the ruler.

Move the image intensifier to the distal humerus.

Take an AP image of the distal humerus, centering the beam at the nail insertion site. Verify fracture reduction and position of ruler tip.

Reading directly from the ruler image, select the length at, or just proximal to, the distal margin of the planned insertion point.

Note: When choosing nail length, the measured canal length indicates actual nail length (retrograde example, for canal measured 240 mm with the radiographic ruler, select a 240 mm nail).



Place ruler along lateral aspect.



Read nail length.

Confirm nail diameter

With a long forceps, place the ruler against the arm so the diameter gauge is centered over that portion of the medullary canal that will contain the nail shaft.

When the medullary canal can be visualized through the gauge, the nail can be inserted. Choose a nail that will fill as much of the proximal canal as possible.

Since both nail sizes (7.5 mm and 9.0 mm) have the exact same diameter at the instrumented end of the nail, the distal humerus must always be opened to 10.5 mm with the flexible drill bit [359.079].





Opening the Distal Humerus

Make incision

With the elbow flexed to access the posterior distal humerus, expose the cortex through a tricepssplitting incision.

Identify insertion point

Identify the insertion point, which is approximately 2.5 cm proximal to the olecranon fossa.

Note: As the nail is flexible, the retrograde insertion site does not need to be distally in line with the canal axis as would a solid nail.

3 Position drill bit

Using the Compact Air Drive and Quick Coupling, place the 4.0 mm Drill Bit through the 10.5 mm/4.0 mm Drill Sleeve [359.077], and the 12.5 mm/10.5 mm 30° Protection Sleeve [359.078].

4 Drill

When starting a 4.0 mm pilot hole, begin drilling perpendicular to the posterior cortex, then lower the drill to 30° or less. Stop drilling after passing through the posterior cortex only.

Note: Due to the hardness of the bone, predrilling is performed with a 4.0 mm Drill Bit instead of the awl in retrograde procedures. Also note that the entry hole will be approximately 11 mm. The pilot hole should be positioned so that the enlarged hole will not encroach upon the olecranon fossa.



Retrograde insertion site

Caution: Be aware of the steep slope of the distal lateral condyle when starting the retrograde entry point —make sure the starting hole is centered posteriorly.



Begin drilling perpendicular to the cortex.



Drill at 30° or less through the posterior cortex only.

Insert 2.5 mm Calibrated Reaming Rod

Remove the 4.0 mm drill bit and pass the ball-tipped 2.5 mm Calibrated Reaming Rod into the pre-drilled hole, using the Universal Chuck with T-Handle. Pass the reaming rod proximally into the medullary canal under image intensification. Ensure that the reaming rod enters the medullary cavity and does not penetrate the anterior cortex.

Note: The nail is not cannulated. The reaming rod must be removed prior to nail insertion.



Insert the reaming rod, using the Universal Chuck with T-Handle.

Enlarge entry site

In patients with dense bone, it is necessary to develop the entry site in steps, using sequentially larger reamers and drill bits over the reaming rod.

Ream the distal humerus. Flexible Medullary Reamers, [359.106–359.115] from 6.0 mm to 10.5 mm, may be passed over the reaming rod to prepare the canal for nail insertion.

In young patients or patients with especially dense bone, it may be necessary to ream up to the nail diameter plus 0.5 mm.

Note: See page 13 for guidelines in using the flexible reamers.

Using the Compact Air Drive and Large Quick Coupling, pass the 8.0 mm Flexible Drill Bit over the reaming rod through the 30° Protection Sleeve. Repeat with the 10.5 mm Flexible Drill Bit. Monitor under image intensification.

Note: The 10.5 mm Flexible Drill Bit is necessary in every case, regardless of bone density and whether or not reaming is performed. This drill bit is needed to prepare the entry site to accommodate the nail head.



Use flexible reamers and drill bits to prepare for nail passage. Do not operate these reamers and drill bits in reverse.

Caution: Place the 30° Protection Sleeve firmly against the posterior cortex, and hold it tightly during drilling or reaming. This will ensure that the flexible drill bits and/or flexible reamers enter the canal at the appropriate angle, approximately 30° to the humeral axis. This will help to avoid notching the anterior cortex as the flexible drill bit or reamer is advanced proximally.

Opening the Distal Humerus (continued)

Enlarge entry site (continued)

Note: If the opening techniques previously described are followed, the entry hole will accommodate the shape of the nail head, and will allow easy manual insertion of the flexible nail with little or no hammering and with minimal stress at the entry site.

When drilling and reaming are complete, the 2.5 mm Titanium Calibrated Reaming Rod may be used for intraoperative length verification (see page 25).

Confirm size and shape of entry hole

Insert Nail Trial

Remove the reaming rod and insert the Nail Trial to the level of the removable 15 mm extension piece.

Note: If the Nail Trial does not fit easily into the prepared hole, enlarge the entry hole to accommodate the nail head as necessary using the 3.5 mm/8.5 mm Conical Burr and/or the flexible drill bits.

The conical burr can be used to help direct the canal entry hole posteriorly.

Remember: The 15 mm extension piece will always be removed after retrograde insertion.



Insert the Nail Trial.



Etch on Nail Trial indicates the removable 15 mm extension piece.



Additionally available

Small F-Tool	359.209
Hammer	399.41

Nail Insertion

Assemble the insertion instruments

1 Assemble Connecting Screw through handle Slide the Connecting Screw [359.054] through the Insertion Handle [359.052].

Tighten Connecting Screw

Remove the peripheral wire clip. Pass the Connecting Screw through the 15 mm extension piece of the nail and thread it into the nail head, using the Ratchet Wrench [321.20]. The concave aspect of the nail bend will be oriented toward the Insertion Handle. Tighten securely.

Attach Insertion Cap

Couple the Insertion Cap [359.070] onto the Connecting Screw, gently squeezing the peripheral wires together. Slide the collar over the wires and toward the nail until it locks into place.

The peripheral wires will remain within the collar during nail insertion.



Attach Insertion Cap to Connecting Screw.



Cover peripheral wires with the collar.



Insert Connecting Screw through handle.



Tighten Connecting Screw to nail with Ratchet Wrench.

Caution: Do not remove the protective wire caps from the ends of the peripheral wires. These caps prevent wire "sticks" and are fully autoclavable.

Assemble the insertion instruments (continued)

Attach Slide Hammer

Attach the Slide Hammer [359.036] to the shaft of the Insertion Cap.



Attach Slide Hammer to the shaft of the Insertion Cap.

Insert the nail



Insert nail into canal

Manually insert the flexible nail into the medullary canal. The nail should slide easily into the canal by hand.

Heavy blows with the Slide Hammer are not normally necessary. Should the nail jam at the entry site or in the canal, the slide hammer may be used to back out the nail. If heavy force is needed to seat the nail head, the entry hole should be enlarged as previously outlined.



Note: Flex the nail by bending the Insertion Handle toward the nail tip. This may facilitate insertion by relieving stress on the entry site as the nail slides up the canal.

Nail Insertion (continued)

Insert the nail (continued)

² Seat the nail

Verify fracture reduction and pass the nail across the fracture using manual pressure, or slight taps of the Slide Hammer [359.036] as needed. Finish inserting the nail by seating the nail to the level of the junction of the 15 mm extension piece and the nail head.

Monitor nail passage and fracture reduction under image intensification.

Note: The nail's flexibility allows it to be inserted in an optimum off-axis insertion site, yet it is stiff enough to be used as a reduction aid when passing the fracture site (use the Insertion Handle as a joystick). In addition, the Small F-Tool [359.209] may be used to help with fracture reduction.



Nail may be seated using the Slide Hammer.

Verify nail position

Final nail position can be verified by placing a 3.2 mm Drill Bit through the small drill hole in the Insertion Handle. The check hole for retrograde insertion is closest to the nail tip. This hole marks the junction between the 15 mm extension piece and the nail head.

Caution: Do not leave a fracture gap after reduction and nail passage. As precise apposition of fragments as possible may help prevent delayed union or non-union.



Verify nail position by placing a 3.2 mm Drill Bit through the small check hole closest to the nail tip.

Implants and Instruments for Stiffening and Locking



Stiffening and Locking the Nail (continued)

Stiffen the nail

Remove Insertion Cap

If the Insertion Cap was attached for insertion, remove it from the Connecting Screw. With the button depressed, slide the captivator of the Insertion Cap away from the Connecting Screw. Release the Insertion Cap.

Create incision

Create a stab incision below the purple hole marked "STIFF" on the insertion handle.

Note: Always measure before drilling and inserting the Tension Screw.



2

Measure for 4.0 mm Tension Screw

Insert the Tension Screw Measuring Gauge through the insertion handle and to the bone. Ensure it is completely seated on the cortex. Note the tension screw measurement and remove the gauge.

Note: If the measurement is between two sizes, always choose the shorter length.





Insert the Tension Screw Measuring Gauge.



Insert trocar and protection sleeve

Insert the 11.0 mm/8.0 mm Protection Sleeve and 8.0 mm Trocar through the same hole, marked "STIFF".



Insert the 11.0 mm/8.0 mm Protection Sleeve and 8.0 mm Trocar.

Stiffen the nail (continued)

5

Insert 4.0 mm Drill Sleeve with Bell

Remove the trocar and insert the 4.0 mm Drill Sleeve with Bell into the 11.0 mm/8.0 mm Protection Sleeve.

6

Drill to stop

Drill with the 4.0 mm Drill Bit to the stop. Only the near cortex will be drilled, leaving the nail untouched.



Drill only the near cortex.

Remove drill bit and drill sleeve with bell

Remove the drill bit and 4.0 mm Drill Sleeve with Bell, leaving the outer 11.0 mm/8.0 mm Protection Sleeve in place.

8

7

Insert 4.0 mm Tension Screw

Using the self-retaining 3.5 mm Hexagonal Screwdriver, slide the chosen 4.0 mm Titanium Tension Screw through the sleeve and into the drilled hole.



Insert 4.0 mm Drill Sleeve with Bell into protection sleeve.



Drill to the stop.

Stiffening and Locking the Nail (continued)

Stiffen the Nail (continued)

Insert 4.0 mm Tension Screw (continued)

Holding the Insertion Handle with one hand, apply axial pressure on the screwdriver and turn the Tension Screw into the nail, through the tension block.

Note: As the screw is threaded into the nail, the resistance will increase. This is normal and will decrease to a steady level once the screw cone has cleared the nail. The color-coded ring on the self-retaining screwdriver serves as an approximation of proper screw placement, indicating the head has reached the near cortex. (Always check under image intensification.)



Insert 4.0 mm Tension Screw. **Note:** Do not pull the Insertion Handle away from the drilled hole when inserting the tension screw.



Seat 4.0 mm Tension Screw



Insert the tension screw until its head is seated on the near cortex and the cone has cleared the far side of the nail. Be careful not to split the far cortex; monitor screw placement with the image intensifier.

Note: The tension screw is not bicortical.

Should there be any difficulty stiffening, check:

- *Is the screw in the nail? Check the lateral view under image intensification.*
- *Is the Tension Screw aligned straight on the self-retaining screwdriver? Screw tip may be missing the tension block.*
- *Is the Insertion Handle tightened to the nail? Retighten the Connecting Screw.*
- *Is the Insertion Handle rotated away from the drilled hole?*
- Is the tip of the screw through the near cortex?



Insert 4.0 mm Tension Screw to stiffen nail.

Warning: Do not reuse tension screws. Repeated insertion of a tension screw may strip or otherwise damage the threads, affecting the stiffening mechanism in the nail. If the tension screw is removed, discard it and use a new one.

If a second tension screw is inserted and removed, the internal threads of the nail will also be deformed and the nail should be replaced with a new one.

Lock the nail head

1

Extend incision

Extend the existing stab incision under the blue hole marked "LOCK" in the Insertion Handle.



Pass the 11.0 mm/8.0 mm Protection Sleeve [355.70] and 8.0 mm Trocar [355.75] through the "LOCK" hole.



Insert protection sleeve and trocar.



Remove trocar, then insert 8.0 mm/3.2 mm Drill Sleeve.

Remove trocar and insert drill sleeve

Remove the Trocar and insert the 8.0 mm/ 3.2 mm Drill Sleeve (color-coded blue).

Drill both cortices

Drill through both cortices using the 3.2 mm Calibrated Drill Bit [356.972] (color-coded blue). Stop after penetrating the far cortex. Confirm drill tip position with the image intensifier.

Measure for locking bolt or locking screw

Press the drill sleeve firmly to the cortex and read the measurement on the calibrated drill bit at the top of the sleeve. This reading provides the correct locking screw or locking bolt length.

Alternatively, remove the drill bit and drill sleeve, leaving the protection sleeve in place. Measure the correct locking screw or locking bolt length using the measuring hook of the Locking Bolt Measuring Device [357.792]. Insert the hook into the protection sleeve and through the bone and nail, engaging the far cortex. Make sure the protection sleeve is pressed firmly against the cortex. Read locking screw or locking bolt length directly at the back of the protection sleeve.





Locking screw or locking bolt length can be read directly from the 3.2 mm calibrated drill bit.

357.792





Alternatively, measure with the measuring hook of the Locking Bolt Measuring Device.

Stiffening and Locking the Nail (continued)

Lock the nail head (continued)



Remove drill bit and drill sleeve

Remove the drill bit and drill sleeve from the protection sleeve.

Insert locking bolt

Insert the chosen 4.0 mm Titanium Locking Screw or 3.9 mm Titanium Locking Bolt using the self-retaining 3.5 mm Hexagonal Screwdriver.



Insert 4.0 mm Titanium Locking Screw or 3.9 mm Titanium Locking Bolt.

Lock the nail tip

Reconfirm fracture reduction.

Note: Always use at least one transverse locking bolt through the non-instrumented end of the nail.

Orient the image intensifier to view the proximal humerus.

Make a longitudinal incision over the locking hole. Bluntly dissect to avoid the axillary nerve.

Insert the LM locking bolt using standard freehand technique. AP locking is an added option.



Advancing the Peripheral Wires

During retrograde implantation, the peripheral wires may be advanced into the humeral head to achieve additional rotational stability. It is recommended to lock the nail tip prior to advancing the peripheral wires. In patients with good quality bone, if the peripheral wires are advanced before locking bolt insertion, the wires may distract the proximal fracture fragment. Alternatively, in situations where distraction is unlikely, the peripheral wires may be advanced before locking the nail tip. The peripheral wires may act as a temporary means of stabilizing the nail in these cases, making it easier to lock the nail tip.

Remove protective caps

Remove and discard protective caps from the ends of the peripheral wires.



Remove protective caps.

Align Wire Advancer

Using the Wire Advancer, depress the front button and allow the insert shaft to slide forward until it stops in the full forward position. Release the front button and slide the barrel over one wire until it stops.

Note: For best results align the Wire Advancer so that the peripheral wire is as straight as possible and not crossing the other wires. Ensure that the wires are not bent, kinked, or crossed.



Depress front button and allow insert shaft to slide forward.



Ensure wires are not bent, kinked, or crossed.



Release button and slide the barrel over one wire.

Advancing the Peripheral Wires (continued)

Couple Wire Advancer to Connecting Screw

Depress the front button again (with the button pressed throughout) and push the Wire Advancer

onto the peripheral wire and connecting screw. Listen and look for the audible "snap" as the Wire Advancer couples onto the Connecting Screw. It may be necessary to rotate the Wire Advancer to couple it to the Connecting Screw and prevent wires from crossing.





Couple Wire Advancer to Connecting Screw.

Advance wire

Release the front button, checking for a secure head connection, and advance wire with smooth even pulls on the trigger, monitoring under image intensification. The peripheral wires should be advanced approximately one centimeter.

Caution: When advancing peripheral wires with the Wire Advancer, monitor with image intensification to prevent wire penetration through subchondral bone and into the joint capsule.

Disconnect Wire Advancer and repeat

Depress the quick release lever to release the Wire Advancer and repeat steps until all wires have been advanced.

Note: If there is any problem advancing the wires, remove the Wire Advancer and check the following:

- Are the upper lever and spring fully operational?
- Is the front hole of the barrel clear?
- *Reconnect; are the Wire Advancer and Connecting Screw coupled?*
- Does the shaft slide freely?



Squeeze trigger to advance wire.



Depress the quick release lever and repeat steps until all wires have been advanced.



Implant and Instruments for End Cap Placement



End Cap Placement



Remove the instrumentation from the nail.

Remove the 15 mm extension piece from the nail and wires, using pointed forceps or standard pliers.



Remove 15 mm extension piece.

Cut peripheral wires

Using the Percutaneous Wire Cutter, cut the peripheral wires one at a time. The cut wire will remain within the wire cutter insert tube. After each wire is cut, the wire cutter must be turned upside down to clear wire debris before the next use. This ensures the cut wire will not fall into the wound.

Note: While the peripheral wires should be cut to avoid irritation to the triceps, several millimeters of wire should remain so that the peripheral wires may be retracted back into the nail for later extraction. The excess wire can be bent to avoid irritation, if necessary.



Cut the wires with the Percutaneous Wire Cutter.



Insert 0 mm end cap.



Insert end cap

Insert the Titanium End Cap, 0 mm extension into the nail head, using the self-retaining 3.5 mm Hexagonal Screwdriver.



Implant Removal

Remove end cap

Remove any new bone or callus that may have grown over the end of the nail and insertion site. Next, remove the end cap using the self-retaining 3.5 mm Hexagonal Screwdriver.

Note: Leave the nail stiffened and locked when removing an end cap. This will aid in preventing rotation of the nail.

Caution: Always check prior to removal that the peripheral wires are retracted into the nail tip.



Remove end cap.

Retract peripheral wires

Antegrade implant removal: Verify under image intensification that the peripheral wires have not come out of the nail tip. If the wires have migrated out, remove the 15 mm extension piece and retract the wires back into the nail tip.





Retract wires.



Retrograde implant removal: If the peripheral wires have been advanced, and the patient has a small diameter canal, grab the peripheral wire ends with pliers and retract the wires fully

into the nail tip.

3 Attach Connecting Screw

Fully thread the Connecting Screw into the top of the nail, and tighten with the Ratchet Wrench.

4 Attach Inserter-Extractor

Attach the Inserter-Extractor for the Titanium Tibial and Humeral Nails onto the Connecting Screw. The Connecting Screw has been threaded to allow use of this instrument—it is not recommended to use the Insertion Cap.



Attach Connecting Screw.



Attach the Inserter-Extractor to the Connecting Screw.

Remove tension screw and locking bolts

Remove the tension screw and all locking screws or locking bolts with the self-retaining 3.5 mm Hexagonal Screwdriver.



Remove tension screw and locking screws or locking bolts.

Break nail-tissue bond

To ease nail removal, break the nail-tissue bond with several light forward blows of the slotted hammer. Visually confirm that the nail has shifted position from these blows.



Remove nail

Remove the nail using outward blows of the hammer. Initial outward blows of the hammer are always directed in line with the bent section of the nail head until the bend is at the entry site. Next, continue blows in an arc away from the shaft in order to turn the corner. Flexing the nail toward the tip will reduce pressure on the contact points of the entry site and will ease removal.

Note: For broken nail removal, use the standard solid nail extraction instruments as with any broken solid humeral nail. (This instrumentation will have to go through the rotator cuff.)

If a tension screw breaks, it can be drilled out with the Broken Screw Removal Set.



Implant Specifications

Titanium Flexible Humeral Nail (purple)

Designed for antegrade and retrograde insertion in the left or right humerus.

Material

Titanium-6% aluminum-7% niobium (Ti-6Al-7Nb) alloy

Diameters 7.5 mm and 9.0 mm

Lengths 180–300 mm in 15 mm increments

Distance from nail tip to distal locking holes:

	Antegrade	Retrograde
AP	8.0 mm	14.0 mm
LM	14.0 mm	8.0 mm



4.0 mm Titanium Tension Screws (purple)

Material

Titanium-6% aluminum-7% niobium (Ti-6Al-7Nb) alloy

Lengths

18 mm–26 mm (in 2 mm increments) 30 mm and 34 mm

- 3.5 mm core diameter
- 3.5 mm hex head

3.9 mm Titanium Locking Bolts (blue)

Material

Titanium -6% aluminum-7% niobium (Ti-6Al-7Nb) alloy

Lengths

18 mm-50 mm in 2 mm increments

- 3.3 mm core diameter
- Self-cutting trocar tip
- 3.5 mm hex head

4.0 mm Titanium Locking Screws (blue)

Material

Titanium -6% aluminum-7% niobium (Ti-6Al-7Nb) alloy

Lengths

18 mm-50 mm in 2 mm increments

- 3.3 mm core diameter
- Self-cutting trocar tip
- 3.5 mm hex head



Titanium End Caps (purple)

Protects nail threads from tissue in-growth

Material

Titanium-6% aluminum-7% niobium (Ti-6Al-7Nb) alloy

0 mm Extension

- Recommended for retrograde approach
- 3.5 mm hex head

15 mm Extension

- Required for antegrade implantation to prevent migration of the 15 mm extension piece
- 3.5 mm hex head

Titanium Flexible Humeral Nail Insertion and Locking Sets

with Locking Bolts [105.595] with Locking Screws [105.599]



Set Graphic Case [304.555], shows summary of stiffening technique and includes removable Screw Rack [304.556].

Set Contents

Instruments

314.11	Holding Sleeve (for 3.5 Hex Screwdriver)
314.271	3.5 mm Hexagonal Screwdriver, self-retaining
315.31°	3.2 mm Three-Fluted Drill Bit, quick coupling, 145 mm
321.20	Ratchet Wrench, 11 mm width across flats
351.019	Medium Awl
355.70	11.0 mm/8.0 mm Protection Sleeve
355.72	8.0 mm/3.2 mm Drill Sleeve
355.75	8.0 mm Trocar
356.972⁰	3.2 mm Three-Fluted Drill Bit, quick coupling, 215 mm, 82 mm calibration
357.792	Locking Bolt Measuring Device, 16 mm to 80 mm
358.681	3.5 mm/8.5 mm Conical Burr, quick coupling, 110 mm
359.036	Slide Hammer
359.052	Insertion Handle
359.054	Connecting Screw
359.058	Radiographic Ruler

Implants⁰

3.9 mm Titanium Locking Bolts (in Set 105.595)

•	,		
458.18	18 mm	458.36	36 mm
458.20	20 mm	458.38	38 mm
458.22	22 mm	458.40	40 mm
458.24	24 mm	458.42	42 mm
458.26	26 mm	458.44	44 mm
458.28	28 mm	458.46	46 mm
458.30	30 mm	458.48	48 mm
458.32	32 mm	458.50	50 mm
458.34	34 mm		

4.0 mm Titanium Locking Screws

(in Set 10	5.599)		
458.818	18 mm	458.836	36 mm
458.820	20 mm	458.838	38 mm
458.822	22 mm	458.840	40 mm
458.824	24 mm	458.842	42 mm
458.826	26 mm	458.844	44 mm
458.828	28 mm	458.846	46 mm
458.830	30 mm	458.848	48 mm
458.832	32 mm	458.850	50 mm
458.834	34 mm		

359.064°	4.0 mm Drill Bit, quick coupling, 136 mm stop, 171 mm
359.065	4.0 mm Tension Screw Drill Sleeve with Bell
359.070	Insertion Cap
359.073	Wire Advancer
359.076	Tension Screw Measuring Gauge
359.077	10.5 mm/4.0 mm Drill Sleeve
359.078	12.5 mm/10.5 mm 30° Protection Sleeve
359.079	10.5 mm Flexible Cannulated Drill Bit, large quick coupling, 250 mm
359.081	8.0 mm Flexible Cannulated Drill Bit, large quick coupling, 250 mm
359.083S*	2.5 mm Titanium Calibrated Reaming Rod, 850 mm, sterile
359.085	Nail Trial
359.090	Percutaneous Wire Cutter
360.03°	8.0 mm Cannulated Drill Bit, large quick coupling, 190 mm
393.10	Universal Chuck with T-Handle
511.414	3.2 mm Three-Fluted Drill Bit, quick coupling, brad point, 150 mm

4.0 mm Titanium Tension Screws

475.082	18 mm	475.086	26 mm
475.083	20 mm	475.087	30 mm
475.084	22 mm	475.088	34 mm
475.085	24 mm		

Titanium End Caps

475.091	0 mm extension
475.093	15 mm extension

^o Available nonsterile or sterile-packed.
Add "S" to catalog number to order sterile product.
*Also available nonsterile

Titanium Flexible Humeral Nail Sets^o

7.5 mm/9.0 mm Titanium Flexible Humeral Nail Set [145.598] (consists of both sets shown below)

145.595	7.5 mm Titanium Flexible Humeral Nail Set
304.596	7.5 mm Implant Tray for Flexible Humeral Nails
304.599	Lid for Flexible Humeral Nail Implant Tray

7.5 mm Titanium Flexible Humeral Nails

475.042	180 mm
475.043	195 mm
475.044	210 mm
475.045	225 mm
475.046	240 mm
475.047	255 mm
475.048	270 mm
475.049	285 mm
475.050	300 mm



145.596	Humeral Nail Set
304.597	9.0 mm Implant Tray for Flexible Humeral Nails
304.599	Lid for Flexible Humeral Nail Implant Tray

-1 - - - 11 - 1 -

9.0 mm Titanium Flexible Humeral Nails

475.242	180 mm
475.243	195 mm
475.244	210 mm
475.245	225 mm
475.246	240 mm
475.247	255 mm
475.248	270 mm
475.249	285 mm
475.250	300 mm

^o Sets and implants available nonsterile or sterile-packed. Add "S" to catalog number to order sterile product. Sterile sets do not include implant trays.

Humeral Medullary Reamer Set [105.596]



Flexible Medullary Reamers, flat wire, 385 mm

	Diameter		Diameter
359.106	6.0 mm	359.111	8.5 mm
359.107	6.5 mm	359.112	9.0 mm
359.108	7.0 mm	359.113	9.5 mm
359.109	7.5 mm	359.114	10.0 mm
359.110	8.0 mm	359.115	10.5 mm

For use with a 2.5 mm Titanium Calibrated Reaming Rod, 850 mm [359.083]

Also Available

- 150.16 Compact Air Drive II Set
- 359.209 Small F-Tool
- 399.41 Hammer, 350 grams
- 332.20 Slotted Hammer
- 356.49 Inserter-Extractor for Titanium Tibial and
- Humeral Nails
- 359.086S Removal Adaptor, sterile for Flexible Humeral Nails

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