Antegrade Femoral Nail (AFN)

Surgical Technique
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**Warning**

This description is not sufficient for an immediate application of the instrumentation. An instruction by an experienced surgeon in handling this instrumentation is highly recommended.
**Indications/contraindications**

**AFN Standard locking**

- Shaft fractures (32-A, B, C)
  - Without (32-A [1–3].1 subtrochanteric section)
  - Without (32-B [1–3].1 subtrochanteric section)

**AFN Reconstruction locking**

- Subtrochanteric fractures (Fig. 1)
  - (32-A [1–3].1 subtrochanteric section)
  - (32-B [1–3].1 subtrochanteric section)
- For double ipsilateral fractures consisting of a combination of shaft fractures 32-A, B, C and femoral neck fractures 31-B (Fig. 2)

**Contraindications**

- Isolated femoral neck fractures
- Supracondylar fractures (localisation 32)
- Intertrochanteric fractures
- Pertrochanteric fractures
The Antegrade Femoral Nail is available in diameters of 9, 10, 11, 12, 13, and 14mm. Due to the nail’s anatomical design, nails are required for the left and the right femur.

**AFN implants**

Standard locking implants

- End Cap (0–20mm extension; diameters 9/10, 11/12, 13/14mm)
- Proximal diameters: 13–17mm
- 4.9mm Locking Bolt
- Lengths 26–100mm (in 2mm increments)
- Anatomical 6° ML angle
- 1500mm bending radius
- Cannulated for reamed/unreamed insertion
- Lengths 300–480mm (in 20mm increments)
- The Antegrade Femoral Nail (AFN) is available in titanium alloy TAN (Ti-6Al-7Nb)
- Longitudinal grooves starting from 11mm diameter for optimal insertion
- A choice of static or dynamic interlocking
- Bevelled distal nail end minimizes stress concentration
Reconstruction locking implants

- End cap (0–20mm extension in 5mm increments for diameters of 9/10, 11/12, 13, and 14mm)
- Proximal diameters: 13, 15, and 17mm
- 6.5mm Hip Screw
- Lengths 60–130mm (in 5mm increments) featuring insertion safety stop
- Anatomical 6° ML angle
- 1500mm bending radius
- Cannulated for reamed/unreamed insertion
- Lengths 300–480mm (in 20mm increments)
- The Antegrade Femoral Nail (AFN) is available in titanium alloy TAN (Ti-6Al-7Nb)
- Longitudinal grooves starting from 11mm diameter for optimal insertion
- A choice of static or dynamic interlocking
- Bevelled distal nail end minimizes stress concentration
**Preparation**

**Patient positioning**

Position the patient supine on a fracture or radiolucent operating table. Place the contralateral leg on a leg support, and orient it intraoperatively. Position the C-arm of the image intensifier in such a way that true AP and lateral views of the proximal femur are possible, and check it pre-operatively.

To ensure unimpeded access to the medullary cavity, abduct the upper body approximately 10–15° to the contralateral side (or abduct the affected leg by 10–15°).

**Note:**

There are different positioning types:

- Supine + normal operating table
- Supine + normal operating table and distractor
- Supine + fracture table
- Lateral position + normal operating table
- Lateral position + normal operating table and distractor
- Lateral position + fracture table
**Fracture reduction on the fracture table**

If possible, carry out a closed preoperative reduction of the fracture under image intensifier control. Exact reduction and secure fixation of the patient to the operating table are essential for easy handling and a good surgical result.

Use of the large distractor is also possible.

**Use of the distractor**

The application of the distractor can be helpful in many types of fractures, for old injuries, or when the assistants are inexperienced. Using standard techniques for applying the distractor, insert the distal Schanz screw laterally without image intensification at the level of the upper margin of the patella. The middle of the femur is easy to find with the drill bit. Insert the proximal Schanz screw under image intensification into the femur to allow the AFN to enter the medullary canal on the lateral side of the screw.

After mounting the connecting rods, distract the main fragments and achieve approximate reduction and length correction. An alternative procedure involves inserting the proximal Schanz screw for the distraction from the lateral side. Place the distractor so that the nail can pass it easily during insertion.
Antegrade Femoral Nail (AFN) – Surgical Technique

Determine nail length

A. Measure with the measuring device under image intensification

Position the image intensifier for an AP view of the proximal femur (position 1). Use long forceps to hold the Measuring Device (319.021) alongside the lateral aspect of the thigh parallel to and at the same level as the femur.

Adjust the C-arm of the image intensifier so that the beam is centred between the femur and the measuring device; this will prevent magnification errors. Adjust the measuring device until its proximal end is level with the tip of the greater trochanter.

Mark the skin at the top of the measuring device.

Move the image intensifier to the distal femur end (position 2), replace the proximal end of the measuring device at the skin mark and take an AP image of the distal femur. Verify the fracture reduction.

Read the nail length directly from the image of the measuring device, selecting the measurement at or just proximal to the epiphyseal scar, or at the chosen insertion depth.

B. Measure the contralateral femur

Measure the contralateral femur from the tip of the greater trochanter to the lateral femoral condyle. Subtract 20mm from the measured length and select the next smaller nail length.

Example:

<table>
<thead>
<tr>
<th>Length</th>
<th>Adjusted Length</th>
<th>Difference</th>
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</thead>
<tbody>
<tr>
<td>400mm</td>
<td>380mm</td>
<td>20mm</td>
</tr>
<tr>
<td>399mm</td>
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<td>20mm</td>
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<tr>
<td>398mm</td>
<td>378mm</td>
<td>20mm</td>
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<td>381mm</td>
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<tr>
<td>380mm</td>
<td>360mm</td>
<td>20mm</td>
</tr>
<tr>
<td>379mm</td>
<td>359mm</td>
<td>20mm</td>
</tr>
</tbody>
</table>
Determine nail diameter

Determine the distal nail diameter by placing the AO/ASIF planning template on an AP image over the isthmus.

Alternative:
Under image intensifier control, place the Measuring Device (319.021) on the femur, and position the square marking over the isthmus. The corresponding nail diameter may be used if the transition to the cortex is still visible both on the left and the right side of the marking.

Surgical approach

Palpate the greater trochanter.
Make a 5cm incision approximately 5 to 10cm proximal of the tip of the greater trochanter. Make a parallel incision in the fascia of the gluteus medius and split the gluteus medius in line with the fibres.
Surgical technique for the AFN

Determine nail insertion point and insert guide wire

In the AP view, the nail insertion point is normally found on the tip or slightly lateral to the tip of the greater trochanter in the curved extension of the medullary cavity.

The mediolateral angle of the implant is 6°. This means that the 2.8mm Guide Wire (357.039) must be inserted laterally at an angle of 6° to the shaft. The guide wire can be inserted either manually with the Universal Chuck with T-Handle (393.100) or with the COMPACT™ AIR DRIVE and the quick coupling for Kirschner wires.

In lateral view, insert the guide wire in the centre of the medullary cavity to a depth of about 15cm.
Insert the Protection Sleeve 20.0/17.0 (357.001) with the Drill Sleeve 17.0/2.8 (357.002) and the 2.8mm trocar. Remove the trocar.

**Percutaneous technique:**
insert the guide wire through the Protection Sleeve 20.0/17.0 (357.001) and the Drill Sleeve 17.0/2.8 (357.002). Then remove the drill sleeve 17.0/2.8.
Open the femur

Depending on the selected nail diameter, guide the appropriate cannulated 14mm, 16mm, 18mm Drill Bit (356.703, 356.704, 357.005) (see table below) through the Protection Sleeve 20.0/17.0 (357.001) over the guide wire, and ream manually with the Universal Chuck with T-Handle (393.100) to the stop on the protection sleeve. Remove both protection sleeve and guide wire. Do not reuse the guide wires, but dispose of them.

<table>
<thead>
<tr>
<th>AFN</th>
<th>Drill bit</th>
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<tbody>
<tr>
<td>Distal dia.</td>
<td>Proximal dia.</td>
</tr>
<tr>
<td>9mm</td>
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</tr>
<tr>
<td>10mm</td>
<td>13mm</td>
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<td>12mm</td>
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<tr>
<td>14mm</td>
<td>17mm</td>
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Alternative using the reverse awl

Open the femur or enlarge the entry point with the cannulated 14mm, 16mm, 18mm Reverse Awl (356.710, 356.711, 357.008) (see table below). Use the Tissue Protector (351.050) to spare soft tissues. Drive the awl over the guide wire into the femur until the marking on the awl’s shaft is level with the trochanter tip.

<table>
<thead>
<tr>
<th>AFN</th>
<th>Reverse awl</th>
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<tbody>
<tr>
<td>Distal dia.</td>
<td>Proximal dia.</td>
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<tr>
<td>9mm</td>
<td>13mm</td>
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<tr>
<td>10mm</td>
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<td>11mm</td>
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<td>13mm</td>
<td>17mm</td>
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<tr>
<td>14mm</td>
<td>17mm</td>
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</table>
Ream shaft

Alternative
In some cases, reaming of the shaft may be necessary. Use the SYNTHES® SynReam Instrument Set (175.500) to do so.
Open the femur and insert the reaming rod. Pass the fracture zone and position the reaming rod in the centre of medullary cavity end (Fig. 1).
Start reaming with a 8.5mm medullary reamer.
Continue reaming using progressive size reamers in 0.5mm increments.
The diameter of the last reamer used should be 1–2mm larger than that of the nail.

Note:
The fracture can also be reduced using the reduction attachment of the SynReam Instrument Set (175.500) (Fig. 2).
Assemble instruments

Guide the Connecting Screw (398.335) through the Insertion Handle (357.521) and secure the nail tightly to the insertion handle using the Hexagonal Screwdriver (357.515) (Fig. 1). Diameter and length of the nail have already been determined during surgical preparation.

Ensure that the connection is tight (retighten, if necessary) to avoid deviations when inserting the screws through the insertion handle. Do not attach the aiming arm yet.

Couple the insertion handle to the nail so that the handle is oriented laterally (the convex side of the nail bow marked „ANTERIOR“ faces anteriorly) (Fig. 2).
Thread the Driving Cap (357.180) onto the insertion handle and tighten it. Slide the Ram with Handle (357.250) onto the Hammer Guide (357.220/221) and turn the handle to lock it in place. Slide this assembly onto the proximal end of the driving cap and finger-tighten the assembly (Fig. 3).

Mount the Ram with Handle (357.250) onto the Hammer Guide (357.220/221) (Fig. 4).

**Note:**
The surgeon may also use the 700g Hammer (399.430) instead of the ram with handle and the hammer guide, and strike directly on the proximal end of the driving cap.
Quick coupling connection

The insertion instrument set is also available with quick coupling connection making the assembly much easier.

Note:
Direct hammering with the 700g Hammer (399.430) instead of the ram with handle and the hammer guide is possible, but only with the Protective Cap for quick coupling connection (357.601) (Fig. 5).
Reamed technique

Once the guide wire rests securely in the distal main fragment, use slight rotational movements to insert the implant manually into the femur opening while the insertion handle points anteriorly (fig. 1). Continue the manual insertion of the implant; both the insertion handle and the nail will turn laterally (fig. 2). After a 90° rotation, the final position of the insertion handle will be in the LM plane (fig. 3). Use image intensification to verify the passage of the nail across the fracture zone.
Insert the nail

Unreamed technique
Use slight rotational movements to insert the nail manually into the femur opening while the insertion handle points anteriorly. Push the implant manually to the fracture; both the insertion handle and the nail will turn laterally (compare illustrations 1–3, page 18). Insert the guide wire. Reduce the fracture using the nail and the insertion handle, and guide the guide wire across the fracture line.

Verify the position of the guide wire in the distal fragment und correct it, if necessary. Advance the nail to the desired position. If the nail cannot be pushed any further, select a smaller nail diameter or ream the medullary cavity, otherwise a fracture of the femur might occur.

Use light hammer blows to seat the nail into the metaphysis, leaving the proximal nail end at or just below the level of the tip of the greater trochanter. To avoid locking inaccuracies, recheck whether the connecting screw is secured tightly to the nail.

If nail over-insertion into the medullary cavity is required to ensure optimal positioning of the locking implants, the surgeon may extend the nail length with an end cap (see page 35, insert the end cap).

Remove the guide wire.

Note:
During insertion of a cannulated nail, the cannulated Hexagonal Screw-driver Shaft (357.516) may be used to retighten the connecting screw over the guide wire.
**Proximal locking**

**Standard locking**

The Antegrade Femoral Nail AFN allows standard static locking for the fixation of femoral shaft fractures.

**Indications**

Indications/contraindications, see page 4.

Mount the AFN Aiming Arm (357.522) onto the insertion handle. Insert two 4.9mm locking bolts for static, transverse locking.

**Note:**

Check the position of the proximal nail end by inserting a guide wire through the insertion handle. The position of the locking bolt can be verified by placing guide wires on the surface of the insertion handle. To ensure the correct anteversion of the implant, insert an additional guide wire into the femoral head along the ventral cortex of the femoral neck.

**Use the image intensifier for AP and axial control.**
Make a stab incision and insert the drill sleeve assembly consisting of Protection Sleeve 11.0/8.0 (357.760), Drill Sleeve 8.0/4.0 (357.710) and 4.0mm Trocar (357.750), into the distal hole of the insertion handle (marked stat.) and advance it to the bone.

Remove the trocar.

Drill through both cortices with the calibrated 4.0mm Drill Bit (356.980), stopping the drill immediately after penetrating the far cortex. Confirm the drill bit position using the image intensifier. Make sure that the drill sleeve is pressed firmly to the cortex, and read the length of the locking bolt directly from the calibrated drill bit protruding at the back of the drill sleeve.
Note:
There is no need to calculate the length of the bolt as the calibrated drill bit provides direct measurement. However, since the drill bit position directly represents the locking bolt position in the bone, the locking bolt will be too long if the drill bit is over-inserted, or if the drill sleeve is not pressed to the lateral cortex.
To prevent measuring errors, use the “pause and consider” method: temporarily stop the drill when the bit hits the far cortex. Press the drill sleeve to the lateral cortex; continue drilling until the tip of the drill bit just penetrates the far cortex. Read the locking-bolt length directly off the drill-sleeve back.

To use the Depth Gauge for Locking Bolts (357.790), remove the drill sleeve, measure through the protection sleeve using standard depth gauge technique, and add 2–4mm to the reading to ensure thread engagement in the far cortex. Use the hexagonal screwdriver to insert the locking bolt through the protection sleeve.
Repeat this procedure to insert the second proximal locking bolt.
Reconstruction locking

The hip screw ensures secure fixation of the proximal fragment in sub-trochanteric fractures with or without detached lesser trochanter, and in femoral neck fractures.

Indications

Indications/contraindications, see page 4.

Assemble instruments

See page 15.

Mount the AFN Aiming Arm (357.522) onto the insertion handle. Reconstruction locking requires the insertion of two 6.5mm hip screws.

Note:

The position of the nail can be verified by placing a guide wire onto the insertion handle. Check the position of the nail end by inserting a guide wire into the insertion handle. To ensure correct anteversion of the implant, insert an additional guide wire into the femoral head on the ventral side of the femoral neck.

Insert both hip screws

Insert these screws using the pink drill sleeve assembly consisting of Protection Sleeve 11.5/9.0 (356.705), Drill Sleeve 9.0/2.8 (356.706) and 2.8mm Trocar (356.707).
**Insert guide wire for caudal hip screw**

Make a stab incision and insert the drill sleeve assembly through the corresponding pink distal drill hole of the aiming arm to the bone. Mark the femur and remove the trocar.

Insert a new 2.8mm Guide Wire (357.039) through the drill sleeve into the bone, and check both direction and position under the image intensifier in AP and axial views. Select a position in the caudal area of the femoral head so that both proximal screws can be inserted. Insert the guide wire subchondrally or a maximum of 5mm away into the femoral head. The final position of the guide wire should be in the centre of the lower half of the femoral neck. In lateral view, the wire should be positioned in the centre of the femoral neck.

**Note:**
If the nail has to be repositioned, remove the guide wire, protection sleeve and drill sleeve. The nail can now be repositioned by rotation, deeper insertion or partial retraction. Reinsert the drill sleeve assembly and the guide wire.
Insert guide wire for cranial hip screw

Make a stab incision and insert the second drill sleeve assembly through the proximal pink drill hole of the aiming arm to the bone. Mark the femur and remove the trocar.

Insert a second, new 2.8mm Guide Wire (357.039) subchondrally through the drill sleeve into the femoral head.

Verify direction and position in AP and lateral views of the image intensifier.
Measure length of caudal hip screw

It is recommended to start with the insertion of the caudal hip screw. Remove the Drill Sleeve 9.0/2.8 (356.706) and insert the Direct Measuring Device (357.042) over the Guide Wire (357.039) through the Protection Sleeve (357.705) to the bone, and determine the length of the required hip screw. Read the length of the hip screw directly off the measuring device.

Note:
As the screw head is included in the total length of the screw, we recommend to round up and take the next larger hip screw.
Set reamer for caudal hip screw

Now set the measured length on the reamer by securing the fixation sleeve in the appropriate position. The correct length is indicated on the side of the fixation sleeve facing the reamer tip.

Remove the caudal guide wire.

Drill hole for caudal hip screw

Use the 6.5/4.5mm Reamer (356.702) to drill to the stop. The secured Fixation Sleeve (356.701) prevents further drilling.

- Verify direction and position in AP and lateral views of the image intensifier.

Tapping is not required due to the self-tapping tip of the hip screw.
Insert caudal hip screw

Use the Hexagonal Screwdriver (356.708) to insert the selected hip screw to the lateral cortex.

Verify direction and position in AP and axial views of the image intensifier.

Remove the protection sleeve.
Measure length of cranial hip screw

After the insertion of the caudal hip screw, measure the length of the cranial hip screw. Remove the Drill Sleeve 9.0/2.8 (356.706) and guide the Direct Measuring Device (357.042) over the Guide Wire (357.039) through the Protection Sleeve (357.705) until it touches bone, and determine the length of the required proximal hip screw. Read the length of the hip screw directly from the measuring device.

Note:
As the screw head is included in the total length of the screw, we recommend to round up and take the next larger hip screw.
Set reamer for cranial hip screw

Now set the measured length on the reamer by securing the fixation sleeve in the appropriate position. The correct length is indicated on the side of the fixation sleeve facing the reamer tip.

Remove the cranial guide wire.

Drill hole for cranial hip screw

Use the 6.5/4.5mm Reamer (356.702) to drill to the stop. The secured Fixation Sleeve (356.701) prevents further drilling.

Verify direction and position in AP and axial views of the image intensifier.

Tapping is not required due to the self-tapping tip of the hip screw.
Insert cranial hip screw

Use the Hexagonal Screwdriver (356.708) to insert the selected hip screw to the lateral cortex.

Verify direction and position in AP and axial views of the image intensifier.

Remove the protection sleeve.

Compression

Fracture compression can be achieved by alternately tightening both hip screws. This should be done under image intensification to control compression. Be careful not to overtighten the screws to prevent stripping of the thread.

In osteoporotic bone, use a Washer (419.911) to prevent even the larger screw head from penetrating the lateral cortices.
**Distal locking**

**Static locking**

Distal locking is usually performed using two locking bolts. There are two static interlocking possibilities. Position the locking bolt at the proximal end of the locking slot. Depending on the fracture line, it is then possible to occupy the caudal (Fig. 1) or the cranial (Fig. 2) hole.
Dynamic locking

If immediate dynamisation is required, use only the caudal locking slot distally. For secondary dynamisation, insert both locking bolts as described above, and remove the static bolt later. Reconfirm reduction of the distal fragment.

Fig. 3

Fig. 4

Fig. 5
Note:
In dynamisation, there is a risk of the nail penetrating the knee, due to the somewhat deeper position of the nail in reconstruction locking.

Use the Radiolucent Drive Mark II: align the image intensifier with the nail hole to be drilled until a perfect circle is visible in the centre of the screen. Make a stab incision at the incision point.

Use image intensifier control to insert the tip of the Drill Bit (356.980) into the incision, and hold the drill bit oblique to the X-ray beam until the tip is centred in the locking slot. Tilt the drive until the drill bit is in line with the beam and appears as a radio-opaque, solid circle in the centre of the outer ring. The drill bit will nearly fill the locking-hole image. Hold the drill bit in this position and drill through both cortices. Measure the required locking bolt length using the Depth Gauge for Locking Bolts (357.790) adding 2–4mm to the reading to ensure locking bolt engagement in the far cortex.

Use the large Hexagonal Screwdriver (356.708) to insert the bolt. Repeat the procedure for the second distal locking bolt. For static interlocking, position the caudal bolt at the proximal end of the locking slot, for dynamic interlocking at the distal end of the locking slot to allow dynamisation.

Verify direction and position in AP and axial views of the image intensifier.

Note:
If the Radiolucent Drive MARK II is not available, perform distal locking in standard freehand technique using the Drill Bit (356.980).
Insert the end caps

With the insertion handle in place, take an AP image intensification view of the position of the proximal nail end. The nail end should be visible due to the difference in nail and insertion handle diameters.

If the nail end is level with the tip of the greater trochanter, select the green end cap with 0mm extension.

If the proximal nail end is distal to the tip of the greater trochanter, determine the appropriate length of the end cap with the help of the indented notches. Nail extensions of 5, 10, 15 and 20mm are possible.

The following points apply:
- If the indented ring is at the upper rim of the greater trochanter, use the end cap with 10mm extension
- If the base of the cone is level with the upper rim of the greater trochanter, use the end cap with 20mm extension
- End caps with 5 and 15mm extensions are available for finer increments

For additional orientation, insert a 3.2mm guide wire through the appropriate hole of the insertion handle, and verify the guide wire position radiographically.
Loosen the connecting screw and remove the insertion handle.

Insert the hook of the Guide Wire with Hook (356.717) through the selected end cap. Now guide the 4/11mm Hexagonal Screwdriver Shaft (357.516) over the guide wire to the end cap. The end cap is automatically secured as soon as this connection is made.

Guide the cannulated end cap to the proximal end of the nail. Tighten the end cap using the 11mm Ratchet Wrench (321.200). Fully insert the end cap into the nail.

As the final threads of the end cap turn into the nail, you will feel increased resistance. Continue turning until the shoulder of the end cap contacts the proximal nail end. This prevents backout.

**Note:**
- If the indented ring is level with the upper rim of the greater trochanter, use the end cap with 10mm extension
- If the base of the cone is level with the upper rim of the greater trochanter, use the end cap with 20mm extension

Remove the hexagonal screwdriver shaft, the ratchet wrench and the guide wire.
Implant removal

Remove end cap

Remove bone particles from the end cap. Push the 2.8mm Guide Wire with Hook (356.717) hook first through the end cap and take hold. Verify the hold of the guide wire. Use the Hexagonal Screwdriver Shaft 11/11 (356.715) and the Ratchet Wrench (321.200) for this procedure.
Remove locking bolts and hip screws

Remove the locking bolts or hip screws using the hexagonal 3.5mm Screwdriver for AFN (356.708) and the appropriate Holding Sleeve (314.280).

Note:
Before removing the last locking bolt or hip screw, thread the Extraction Screw (356.716) into the proximal nail end. This prevents the nail from rotating in the medullary canal.
Remove nail

Thread the Hammer Guide (357.220) and the Ram with Handle (357.250) into the extraction screw. Thread the extraction screw into the proximal nail end, through the incision made for end cap removal. Finger-tighten the assembly. Remove the remaining locking bolts and extract the nail.
Cleaning

Intra-operative and postoperative cleaning

Use the 2.8mm Stylet (319.460) to clean the cannulations of the instruments intraoperatively.

Clean the instruments postoperatively with the 2.8mm Stylet (319.460) and the 2.9mm Cleaning Brush (319.240).

Subject to alterations.
**Literature**


