stryker

Tornier IM Nail
Humeral Fracture System

Operative technique

Tornier IM Nail
Humeral Fracture System

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This publication sets forth detailed recommended procedures for using Stryker devices and instruments. It offers guidance that you should heed, but, as with any such technical guide, each surgeon must consider the particular needs of each patient and make appropriate adjustments when and as required.

Important

- The patient should be advised that the device cannot and does not replicate a normal healthy bone, that the device can break or become damaged as a result of strenuous activity or trauma and that the device has a finite expected service life.
- Removal or revision of the device may be required sometime in the future.
- Cleaning and sterilization information is provided in the applicable instructions for use.
- Non-sterile devices, including implants and instruments, must be cleaned and sterilized prior to use, in accordance with validated methods.
- Devices that are able to be disassembled should be disassembled prior to point-of-use processing. Additionally, devices with movable components that do not facilitate disassembly should be manually articulated during the point-of-use processing step in order to evacuate additional soils.
- Please remember that the compatibility of different product systems has not been tested unless specified otherwise in the product labeling.
- Consult Instructions for Use (https://ifu.wright.com) for a complete list of potential adverse effects and adverse events, contraindications, warnings and precautions.
- The surgeon must advise patients of surgical risks, and make them aware of adverse effects and alternative treatments.
- An implant whose packaging is open or damaged or whose expiration date has passed must not be used. Every precaution must be taken to ensure sterility when opening the packaging of the implant and during implantation.

Tornier Humeral Nail rationale

The Tornier Humeral Nail has been designed to maximize tuberosity fragment fixation and provide stable support for the humeral head, resulting in improved proximal humeral reconstruction and fixation in osteoporotic bone. The nail design and optimal screw orientations have been chosen after an extensive dimensional analysis of the proximal humerus in addition to revisiting the physiopathology of displaced unstable 2, 3, and 4-part fractures.

The concept of the Tornier humeral nail is based on five basic biomechanical principles:

Humeral head support: the straight nail design acts as a mechanical support for the humeral head fragment under compressive forces to resist valgus/varus subsidence.

Tuberosity-based screw orientation: the proximal screw orientation is based on tuberosity placement (antero-posterior) and not on the position of the humeral head (I.E. Latero-medial). This approach to tuberosity-based fixation orients the screws perpendicular to the fracture lines and to the pull of the rotator cuff muscles.

Nail-based screw fixation: polyethylene insert captures each proximal screw within the nail to provide improved tuberosity fixation in osteoporotic bone, prevent loss of tuberosity reduction, and eliminate screw back-out and loosening. The use of nail-based fixation in this design improves fixation performance over alternative designs using bone-based fixation, creating a more “angular-stable” construct.

Nail centering & stabilization: centering the nail within the medullary canal and stabilizing it using a divergent distal screw pattern provides support and stability of the humeral head fragment during tuberosity reduction.

Rotational nail control: anatomic nail and screw orientation is created using a version rod aligned with the patient’s forearm.

Implant description

Humeral nail design

- Up to 4 cannulated proximal screws
  - 2 Greater tuberosity screws
  - 1 Lesser tuberosity screw
  - 1 medial calcar screw
- PE insert for locking proximal screws
- Cannulated nail design for simplified implantation over a guide wire
- Material: anodized titanium

Green = Right

Blue = Left

Proximal screws design

- 5 mm diameter hexalobe drive improves screw capture during insertion through portals
- Low-profile screw head design minimizes soft tissue disruption
- 8 available screw lengths (ranges from 28 to 56 mm in 4 mm increments)
- Cannulated screw design allows for suture fixation of the fragments
- Material: anodized titanium

Gold = Proximal

Purple = Distal

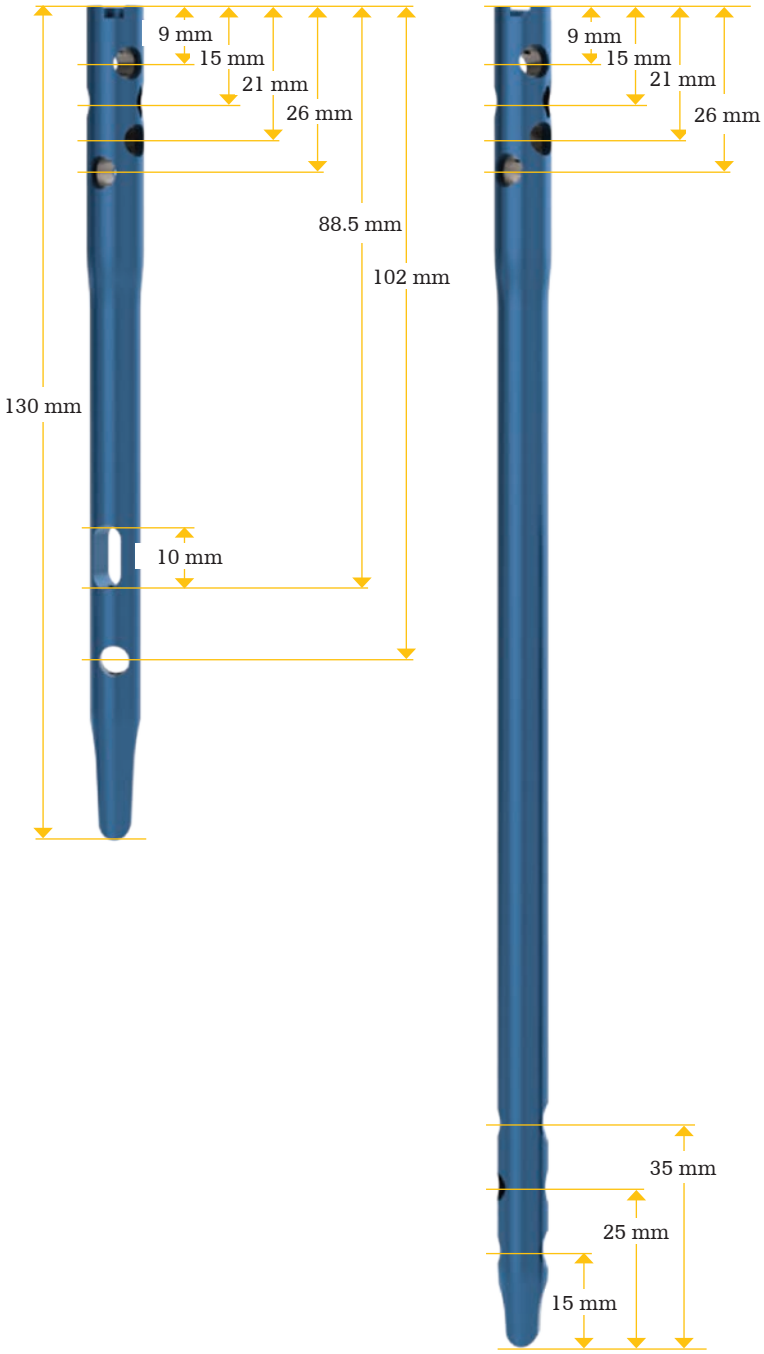
A unique proximal screw pattern

- Provides tuberosity-based fixation
- Resists pull-out forces of the rotator cuff
- Supports the periphery of the humeral head

Distal screws design

- 4.3 mm diameter hexalobe drive improves screw capture during insertion through portals
- 20° divergent screw pattern locks and stabilizes the nail
- 7 available screw lengths (ranges from 20 to 32 mm in 2 mm increments)
- Material: anodized titanium

Implant specifications



Humeral nail

- Nail length: 130 mm
- Proximal diameter: 9 mm
- Distal diameter: 8 mm
- Up to two distal screws to provide fixation
  - 1 dynamic screw
  - 1 static screw - 20° offset

Long humeral nail

- Nail length: 210, 230, 250 & 270 mm
- Proximal diameter: 9 mm (for both the 7 & 8 mm)
- Distal diameter: 7 & 8 mm
- Up to three distal screws to provide fixation
  - 2 static screws anterior to posterior
  - 1 screw 20° offset

Note:
Lengths from the three distal screw holes to the tip of the nail are the same length for all long nails.

Indications and contraindications

Indications for use:

The Tornier Humeral Nail System is intended to provide temporary stabilization of various types of proximal and/or diaphyseal fractures of the humerus.

Types of fractures include, but are not limited to, non-unions, malunions, malalignments, pathological fractures, and impending pathological fractures. Examples of specific indications according to AO classification include type a-fractures, dislocated, type T fractures, dislocated, type c-fractures, with intact humeral head, or humeral fractures according to neer-classification (2, 3 and 4-part fractures).

Contraindications:

The list of contraindications can be found in the IFU (Instruction for use) 0020180 delivered with the implant.

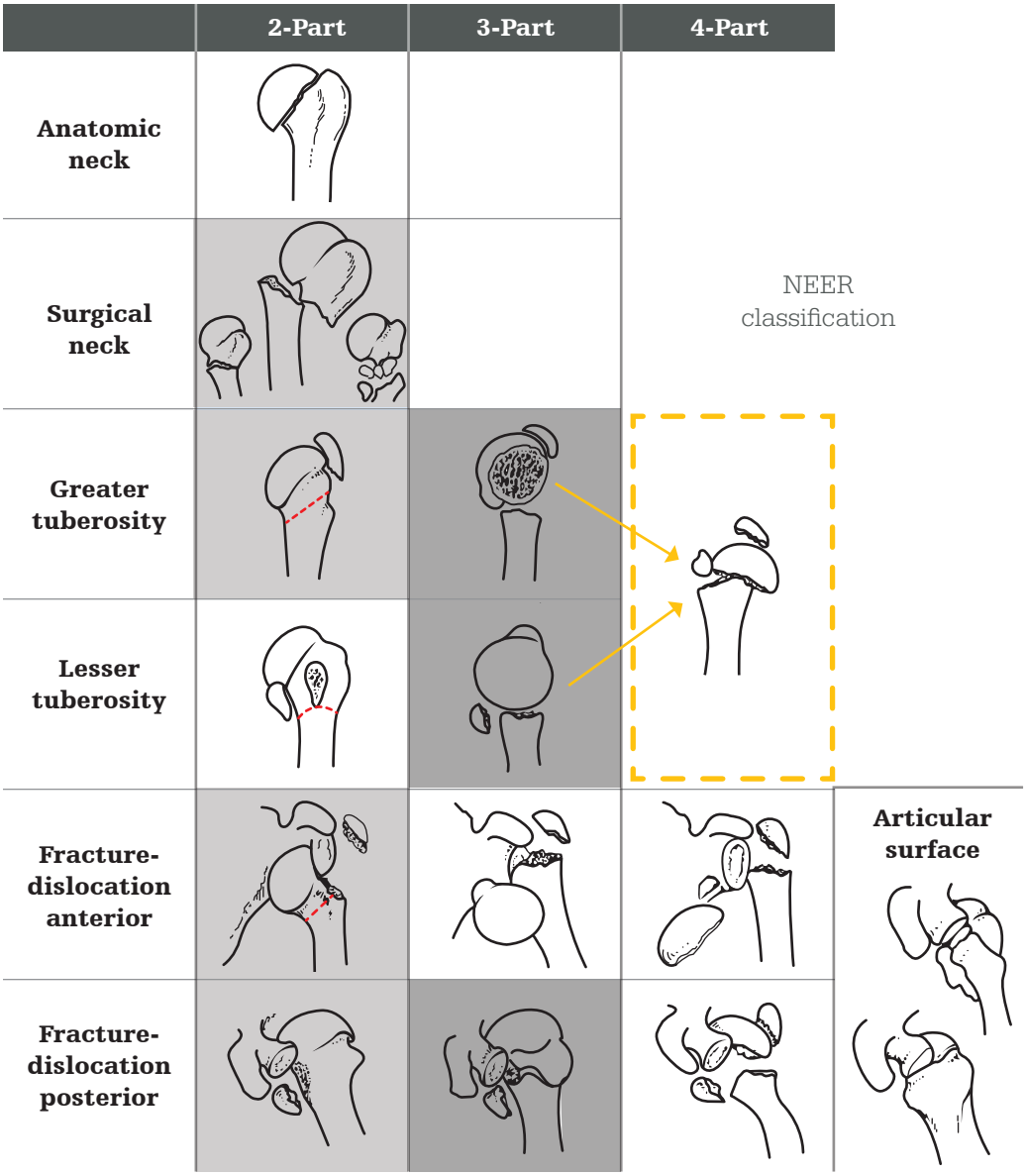
- Infection
- Physiologically or psychologically inadequate patient
- Inadequate skin, bone, or neurovascular status
- Irreparable tendon system
- Possibility for conservative treatment
- Growing patients with open epiphyses
- Patients with high levels of activity
- Growing children with open epiphyses
- Dislocations of radius on ulna that would not allow a radio-humeral articulation
- Rheumatoid arthritis. Evidence of joint narrowing secondary to radio-humeral joint synovitis is not a contraindication to radial head implant replacement combined with elbow synovectomy.

Prior to use of the system, the surgeon should refer to the product package insert for complete warnings, precautions, indications, contraindications and adverse effects. Package inserts are also available by contacting the manufacturer. Contact information can be found on the back of this surgical technique and the package insert is available on the website listed.

Operative technique

Fracture classification

This surgical technique includes the surgical treatment of the following types of fractures: (2-part, 3-part, 4-part)



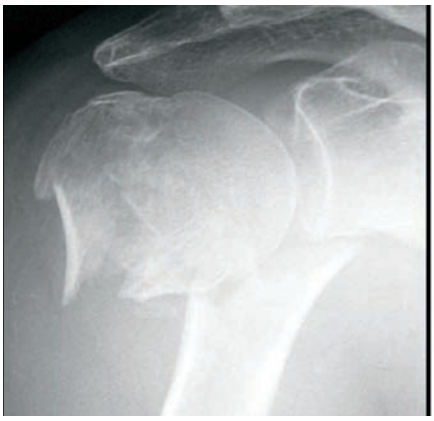
Note:
The Tornier Humeral Nail can be used either percutaneously or in open surgery. The order of insertion of proximal and distal screws relies on fracture types and surgeon's preference.

Operative technique

Two-part surgical neck fracture technique

Retrograde technique

A "retrograde" fragment reduction technique can be performed in the case of a 2-part (surgical neck) fracture.



In the normal manner, the humeral head fragment is manipulated into position, a wire may be inserted through the fragments, and the nail is inserted. Normally, the nail would be positioned 5 mm below the apex of the humeral head by referencing the depth marker on the jig. However, when using the retrograde technique for a 2-part fracture, the nail will be positioned 10 mm below the apex of the head to allow for retrograde compression of the distal humerus.

Surgeon should ensure that:

1) the nail is placed low enough so that the top of the nail is 10 mm below the apex of the head, and

2) rotation is confirmed by aligning the version rod with the forearm.

With the fragments aligned and the nail orientation confirmed, a screw is inserted through the most inferior (static) hole in the nail. In instances where there is good distal fit of the nail within the humeral shaft, the screw can be placed into the dynamic hole if postoperative dynamic impaction of the fracture is desired. This step will lock the nail to the humeral shaft.

With the screw in place, the slaphammer is then assembled to the jig. The slaphammer is then used to create upward "retrograde" compression to the fracture site.

After confirming compression and rotation of the fragment and nail, proximal fixation screws can be inserted into the proximal screw holes to secure the humeral head fragment.

Proximal fixation first technique

Surgery is performed in the modified beach chair or "lazy-lateral" position on a beanbag and radiolucent table. Adequate image intensification should be achieved to visualize the fracture in the anteroposterior and scapular or axillary lateral planes. A superior deltoid-splitting approach or percutaneous technique may be utilized. A small portion of the deltoid and coracoacromial ligament (CAL) can be partially released from the anterior acromion to facilitate medial insertion of the nail.

The fracture is reduced using longitudinal traction, manipulation of the humeral shaft, a small periosteal elevator can be used to "raise" the proximal segment out of varus, or a wire or Schanz pin can be used as a "joystick" to manipulate the humeral head into near anatomic position in relation to the shaft. A longitudinal supraspinatus split is made at the musculotendinous junction to gain access to the humeral head, avoiding violation of the supraspinatus insertion on the greater tuberosity.

Operative technique

Entry into the superior articular surface is achieved via a guide pin and entry hole made using the awl or 10 mm reamer. The proximal segment is fixated using one to four angular stable screws, according to the surgeon's preference. According to the surgeon's discretion static and/or dynamic interlocking is utilized for distal fixation. Dynamic distal interlocking may facilitate natural impaction and healing at the surgical neck.

Three and four-part fractures

Fix the tuberosities, support the head

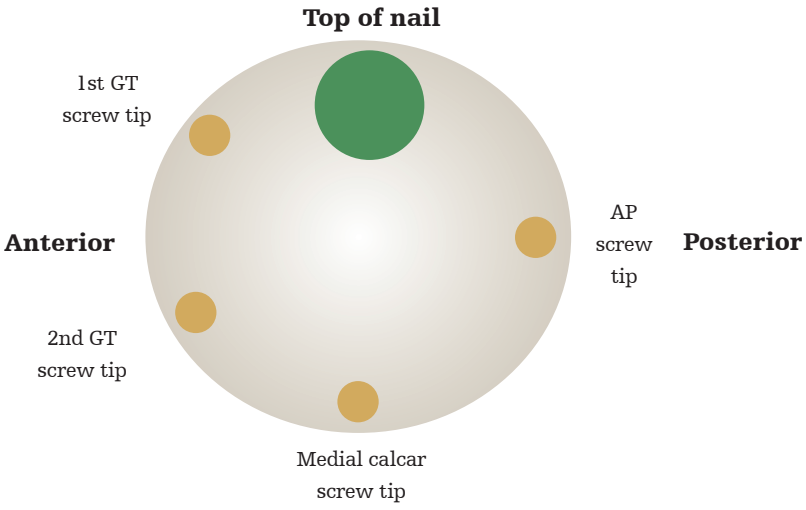
The blood supply to the humeral head is often preserved and the intact soft-tissue bridge works as a "hinge" when the humeral head is raised.

The nail and the screws are used to support the head at its peripherals.

- The top of the humeral head is supported by the nail
- The anterior aspect of the humeral head is supported by the greater tuberosity screws
- The posterior aspect of the humeral head is supported by the lesser tuberosity screw
- The inferior aspect of the humeral head is supported by the calcar screw

The bony and soft tissue structures provide additional stability.

"Supporting" the head
View from lateral aspect of humerus



There are two main techniques to manage multipart fragments fracture:

- Technique 1: The nail is inserted first and used during the fragment reduction
- Technique 2: The fragments are reduced first and the nail is positioned once the reduction is stable

Operative technique

Three-part fracture — technique 1

Derotation technique

A “derotation” technique is performed in the case of 3-part fractures with avulsion of the greater tuberosity. The guide wire is inserted through the rotator cuff, and its position is confirmed by c-arm. While maintaining fracture reduction by manual manipulation, the guide wire is passed through the fracture.

The Tornier humeral nail is then inserted along the guide wire. In cases of excessive internal rotation of the head fragments, a bone hook can be inserted through a separate stab incision for derotation.

The subcapital fracture is reduced percutaneously with the arm in adduction and internal rotation. The Tornier humeral nail is introduced medially to the humeral head fragment. The version rod is placed in internal rotation and the anterior screw is inserted into the lesser tuberosity.

Once the lesser tuberosity is captured, the cephalic head fragment is rotated in external rotation with the help of the nail and instrumentation. The greater tuberosity is then manipulated using a hook.

When anatomically reduced, two locking screws are inserted to hold the greater tuberosity. Following proximal screw fixation, the distal screws are then inserted.

Operative technique

Four-part fracture — technique 1

Either a superior trans-deltoid or deltopectoral approach can be used to address the four-part fracture. To begin, a suture is inserted on the infraspinatus tendon to manipulate the greater tuberosity fragment. Another suture is inserted in the subscapularis tendon to manipulate the lesser tuberosity fragment. The biceps tendon is routinely tenodesed and its intra-articular portion is resected.

The vertical fracture line, located posterior to the bicipital groove, is identified. An elevator is inserted between the fragments and the humeral head is raised to its anatomical position using the greater tuberosity as a reference.

Note:
It is important to keep the medial hinge intact.

An entry point for the nail is created on the articular fragment, taking care not to fracture the articular fragment.

Alternatively, the nail can be inserted directly inside the medullary canal, passing lateral to the head fragment.

The nail is first locked distally with the two distal screws.

Once fixed, the Tornier Humeral Nail can be used to support the head fragment.

Next, the displaced greater tuberosity fragment is identified and reduced by using the sutures in the infraspinatus and placing the arm in external rotation. The greater tuberosity, in most cases, will regain its anatomical position when the articular fragment is elevated and when the arm is turned in external rotation.

Two posterior greater tuberosity locking screws are inserted into the nail to fix the greater tuberosity. The fragment of lesser tuberosity is reduced by using the suture in the subscapularis and then fixed with the anterior lesser tuberosity locking screw.

In case of osteopenic bone, it is recommended to augment fixation with cerclages and tension-band sutures.

Finally, great care should be given to re-attaching the anterior deltoid muscle to the acromion.

Operative technique

Three and four-part fracture — technique 2

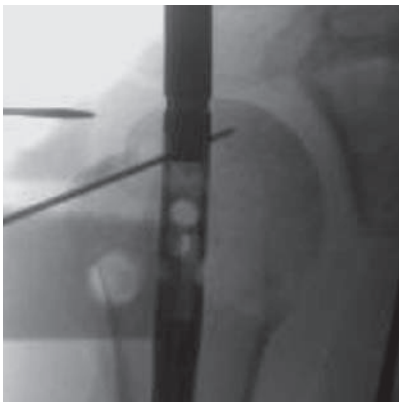
This technique recognizes that anatomic reduction may often be required before placement of the nail. If the nail is placed before anatomic reduction, the jig will potentially interfere with reduction as the rotator cuff is usually still attached to the tuberosities and is often not torn.

The proximal humeral bony fragments are aligned in near anatomic manner and fixed temporarily with k-wires/suture.

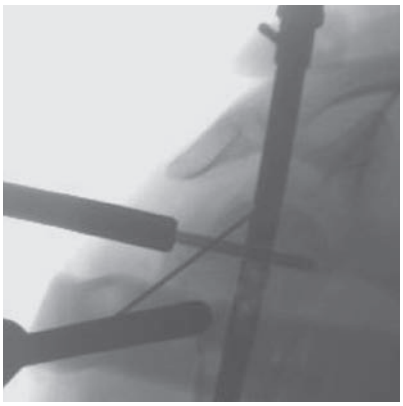
Gaining access through a small incision in the musculotendonous junction of the rotator cuff, the nail is placed into the anatomically aligned humeral head at the appropriate depth below the articular surface.

The first locking screw is placed from posterolateral to anteromedial, fixing the greater tuberosity to the nail. If desired, the screw length can be chosen such that the tip of the screw provides support to the anteromedial aspect of the humeral head.

The second locking screw is placed from anterior to posterior, fixing the lesser tuberosity to the nail construct. If desired, the screw length can be chosen such that the tip of the screw either supports the posterior aspect of the humeral head or provides cortical fixation in the “bare area” of the humeral head.

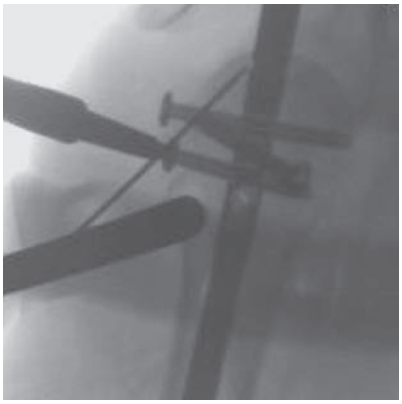


Reduction with nail placed

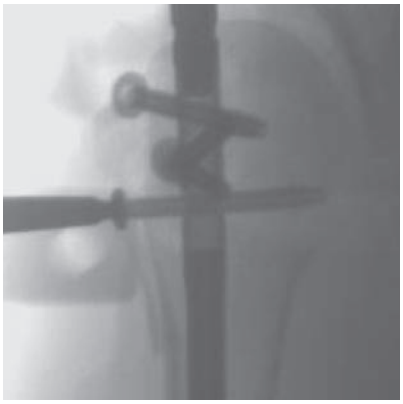


1st GT screw placement

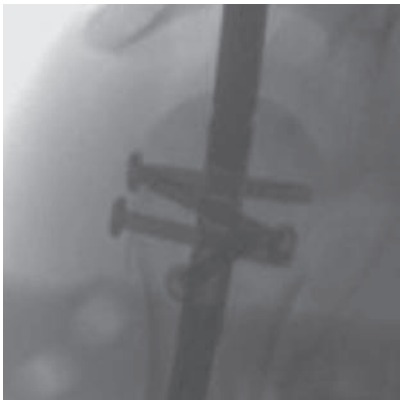
AP LT screw placement



2nd GT screw placement



Calcar support screw placement



Final construct lateral view

Operative technique

The third greater tuberosity locking screw is placed from posterolateral to anteromedial, providing additional fixation of the greater tuberosity to the nail construct. The tip of the screw is chosen such that the tip of the screw supports the inferior anteromedial aspect of the humeral head at the periphery of the head.

The fourth calcar locking screw is placed from anterolateral to posteromedial, with the primary purpose of providing inferior humeral head support at the inferior, medial aspect of the humeral head.

The finished construct provides anatomic fixation and compression of the tuberosities and is unique in providing “five-corner” support of the humeral head. No screw is placed into the central subchondral area of the head. This fixation construct provides optimal humeral head support while minimizing damage to the glenoid if humeral head necrosis and collapse occur.

Finally, the nail is also fixed distally. In instances of a stable proximal construct, the nail is distally fixed using the dynamic slot in the nail. If the canal is large and the proximal segment is comminuted, the fixation needs to be secured using the static distal screw as well. This will prevent toggle and minimize the potential for loss of reduction in the coronal plane.

Final construct AP view

Operative technique

Patient positioning

The patient is placed in the beach-chair position with the elbow flexed at 90°. (Figure 1)

Figure 1

An image intensifier with c-arm is used to provide the necessary anterior-posterior and axillary views.

Note:
Pre- and per-operatory reduction affects the final result. It is important to pay particular attention to the patient's position and the initial position of fragments.

Note:
The dorsal decubitus position is not contra-indicated, but requires a radio-transparent orthopedic table.

Operative technique

Approaches

Three approaches are possible, depending on the fracture type and surgeon preference:

Figure 2

Percutaneous approach

Using an incision on the upper arm no greater than 2 cm, the deltoid muscle is bluntly split to expose the rotator cuff. (Figure 2)

The superior transdeltoid approach

The anterior deltoid is detached from the anterior acromion to expose the rotator cuff. (Figure 3)

Figure 3

The delto pectoral approach

The anterior deltoid muscle is retracted to expose the rotator cuff. (Figure 4)

Figure 4

Operative technique

Reduction of the fragments

A small rasp, periosteal elevator, and/or hook can be used to lift the head and reduce the tuberosities, which can then be fixed with small k-wires. (Figure 5 and Figure 6)

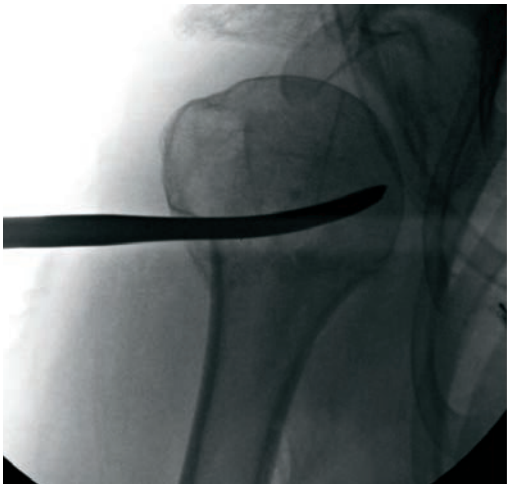


Figure 5

When performing percutaneous reconstruction, pins are introduced to hold fragments in place prior to nail insertion.

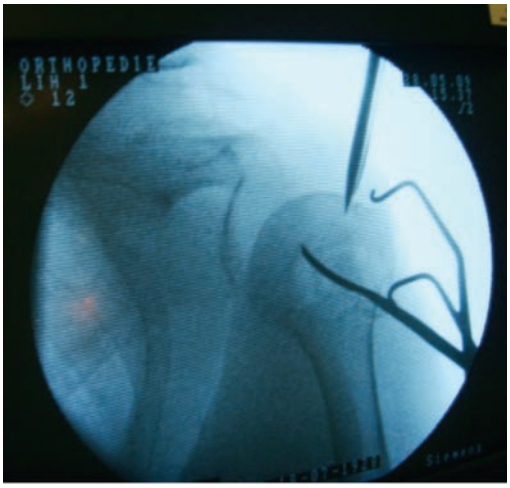


Figure 6

Note:
In some situations, the reduction can be done after the introduction of the wires. This depends on the fracture type and surgeon preference.

Note:
The Tornier Humeral Nail can be inserted and used to facilitate reduction at the surgical neck.

Operative technique

Entry point

The entry point is located in the humeral head, medially, through the supraspinatus muscle or the rotator interval. (Figure 7a & Figure 7b)

The starter awl has marks at varying depths for creating 9, 10, and 11 mm holes, allowing the nail to be inserted.

Figure 7a

Figure 7b

If needed, the cannulated starter awl can be used to introduce the guide wire. (Figure 8)

It is recommended to use fluoroscopic control during this stage to ensure optimal positioning of the guide wire within the medullary canal.

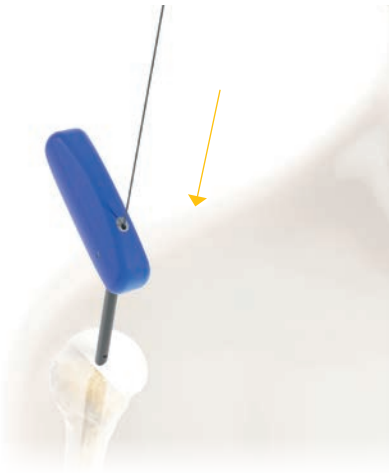


Figure 8

In instances of very dense or sclerotic bone, the 10 mm reamer can be used under fluoroscopic control. (Figure 9)

For long humeral nail, move directly to page 34.

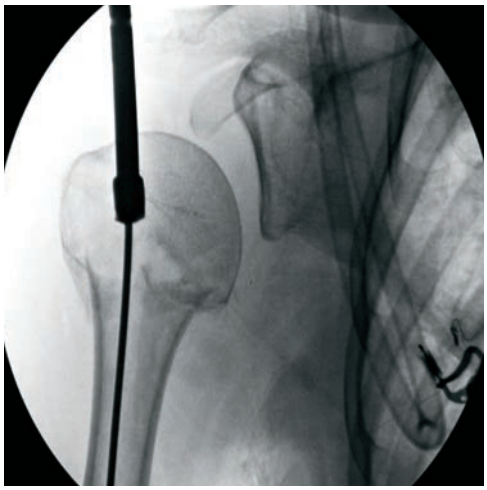


Figure 9

Note:
If the fracture involves the biceps tendon, a tenodesis can be performed at that stage.

Operative technique

Tornier Humeral Jig

The Tornier Humeral Jig is an external targeting device made of radio-transparent carbon fiber that allows accurate positioning of the screws in the nail. (Figure 10)

Color coding engraved marks on the jig identifies the location of each screw (blue for the left nail and green for the right nail, white for common screws working for both sides).

Figure 10

On the proximal part of the jig (Figure 11)

- GT HI for the highest and anterior greater tuberosity screw
- GT LO for the lowest and posterior greater tuberosity screw
- LT for the lesser tuberosity screw
- CTR for the calcar support screw

Figure 11

On the distal part of the jig (Figure 12)

- STC for the static screw
- DYN for the dynamic screw

Figure 12

Note:
An outrigger connection must be assembled if the screw for the lesser tuberosity is needed.

Operative technique

Outrigger connection

An outrigger connection can be assembled when the screw for the lesser tuberosity is needed.

In order to connect the outrigger to the jig, the outrigger should be positioned with the appropriate marking facing up (left for a left shoulder and right for a right shoulder). (Figure 13)

Figure 13

The extension is then connected to the jig by sliding it down in the groove of the jig. (Figure 14)

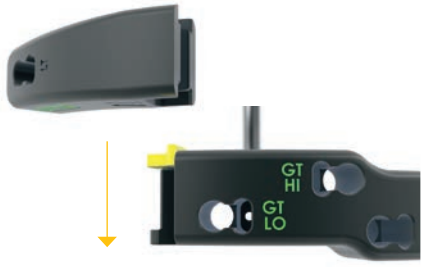


Figure 14

Once the extension is place, the outrigger is locked by pushing the yellow locking tab in the direction of the tip of the outrigger. (Figure 15 & Figure 16)

Figure 15

The yellow locking tab must slide back toward the jig for disassembly of the outrigger.

Figure 16

Operative technique

Jig/humeral nail assembly

Selection of the implant:

Care should be taken to choose the correct nail, depending on the side of the fracture. (green for right and blue for left)

Assembly of the connection bolt and the jig

The connection bolt is inserted into the sleeve of the jig. (Figure 17)

Figure 17

Assembly of the Tornier Humeral Nail with the jig

The humeral nail can be assembled in only one position relative to the jig.

In order to assemble the Tornier Humeral Nail into the bolt, rotate the tip of the nail until the proximal end of the nail fits into the connector. (Figure 18)

The bolt is then threaded into the humeral nail to lock the nail in the proper position. (Figure 19)

Figure 18

Figure 19

The bolt is then tightened with the 12 mm wrench. (Figure 20)

Figure 20

Note:
Once the nail is properly assembled, a visual check will confirm alignment between the nail and targeting jig holes.

Note:
Improper assembly or tightening can compromise the precision of the jig during drilling or insertion of locking screws.

Operative technique

Nail insertion and height adjustment

Nail insertion:

The Tornier Humeral Nail is manually inserted onto the optional guide wire, using gentle rotations to facilitate its progress through the soft tissue. (Figure 21, Figure 22, Figure 23 & Figure 24)

It is critical to not place excessive force on the nail to prevent fragment displacement.

Note:
Do not mallet on the jig.

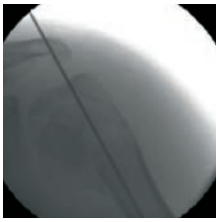


Figure 21

Figure 22

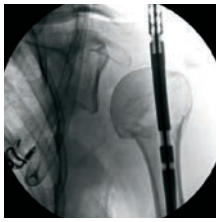


Figure 23

Figure 24

Height adjustment:

It is critical to fully bury the Tornier Humeral Nail below the humeral head to prevent any cuff impingement between the superior cuff and the top of the nail. There are two methods to identify the proper nail depth:

- A groove on the jig connector can be seen under fluoroscopic control which allows the depth of the nail to be verified, even when using the percutaneous approach. (Figure 25) The groove is located 5 mm above the top of the nail, and should be inserted into the humeral head at this depth to avoid leaving the humeral nail proud. (Figure 26).
- It is also possible to insert the 3 mm marker wire into the jig to intra-operatively identify the highest point of the nail (Figure 27a & Figure 27b).

Figure 25

Figure 26

Note:
It is critical to check several views when working under fluoroscopic control to ensure the top of the humeral nail is fully buried into the humeral head.

Figure 27a

Figure 27b

Operative technique

Nail insertion and version adjustment

To restore the anatomic version of the tuberosities and humeral head, a retroversion rod can be assembled to the jig. The retroversion rod is an assembly consisting of the following components (Figure 28):

- 2 rods
- Wrist cradle

Figure 28

The version rod is set at 20° of retroversion relative to the forearm and provides a useful landmark in procedures involving comminutive fractures where all anatomical landmarks have disappeared.

Operative technique

Nail insertion and version adjustment

Assembly of the version rod:

The two version rods are assembled to another so one is in the vertical plane and one in the horizontal plane. (Figure 29)

The wrist cradle is then screwed onto the threaded end of the rod. (Figure 30)

The version rod assembly is inserted into the jig through a hole located at the end of the jig making sure that the flat on the rod is facing medial. (Figure 31)

The version rod provides a version landmark of 20° from the forearm. (Figure 32)

Figure 29

Figure 30

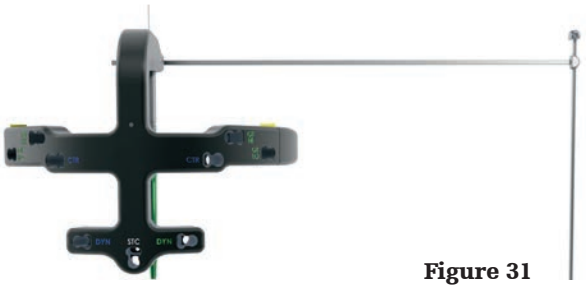


Figure 31

Note:
To avoid rotational malposition of the nail, two additional verifications can be performed.

First, the **arm should be held in neutral rotation** during screw fixation, especially when the proximal segment is reduced first, followed by distal interlocking fixation.

The second is to **verify the position of the fourth proximal screw cannula**, which is designed to face the axis of the humeral head. This cannula can be placed into the jig (but not through the skin) to give the surgeon a general measure of the nail's retroversion. Using fluoroscopy in a true anteroposterior position, this fourth screw guide should be positioned with thirty degrees of retroversion (just like the average retroversion of the humeral head).

Guide wire removal

Once the nail is inserted, it is necessary to remove the guide wire before drilling the screw holes. (Figure 32)

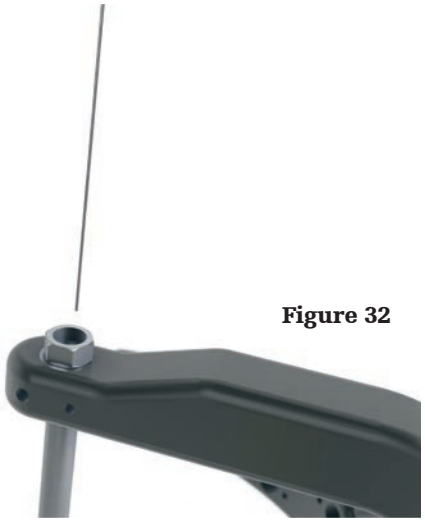


Figure 32

Operative technique

Implantation of the screws

The Tornier Humeral Nail can accommodate 4 proximal screws: (Figure 33)

- 2 Greater tuberosity screws
- 1 Lesser tuberosity screw
- 1 Calcar screw

and 2 distal screws:

- 1 dynamic screw
- 1 static screw

Figure 33

All screws have hexalobe head connection. (Figure 34)

Figure 34

Proximal screws

- The proximal screws are 5 mm screws made of gold anodized titanium.
- They are available in 8 lengths (From 28 mm to 56 mm in 4 mm increments).

Distal screws

- The distal screws are 4.3 mm screws made of purple anodized titanium.
- They are available in 7 lengths (From 20 mm to 32 mm in 2 mm increments).

Note:

- **The number of screws needed varies and is case specific depending on the type of fracture and surgeon preference.**
- **The order of screw implantation varies based on the type of fracture and surgeon preference.**

Operative technique

Proximal screws

Drill sleeve/drill guide/trocar assembly:

All screw positioning for the proximal screws follow these surgical steps:

- Drilling
- Screw measuring
- Screw placement

In order to position proximal screws, the screw sleeve (1), drill guide (2), and trocar (3) are assembled and threaded together before being inserted into the jig. (Figure 35)

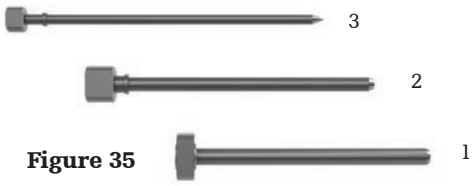


Figure 35

All three components are inserted over one another and screwed together. (Figure 36 & Figure 37)

Figure 36

The internal diameter of the screw sleeve has the same diameter as the proximal screwdriver shaft and the head of the proximal screw to allow for guided screw insertion.

The internal diameter of the drill guide has the same diameter as the drill bit shaft and the distal screw head to provide guided preparation of the screw holes.

The sharp tip of the trocar facilitates the advancement and positioning of the assembly against the bone.

Once assembled, it is critical to check that the 3 components are fully engaged with one another to ensure accuracy during screw placement.

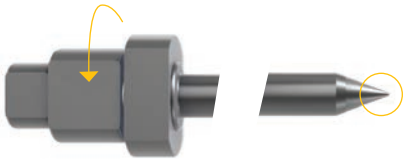


Figure 37

Operative technique

Proximal screws

Drill sleeve/drill guide/trocar positioning:

The locking lever is first positioned into the jig, adjacent to the screw hole to be prepared. (Figure 38)

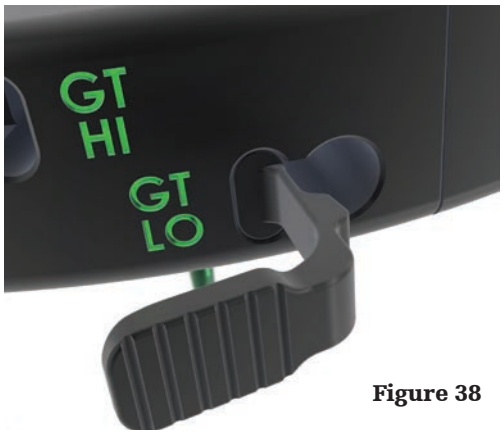


Figure 38

A minimal skin incision is performed at the entry point to facilitate sleeve/guide introduction into the soft tissue.

The assembly (sleeve/guide/trocar) is introduced in the chosen holes and advanced to the bone using a twisting motion. (Figure 39a)

The locking lever is depressed at insertion to allow passage of the sleeve/guide trocar assembly.

Once the tip of the trocar is against the bone, continued advancement of the screw sleeve and drill guide is performed until the knobs are fully separated as shown. (Figure 39b)

The locking lever is then released to lock the sleeve in position.

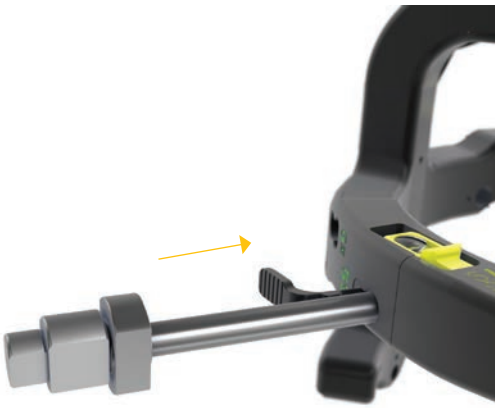


Figure 39a

Figure 39b

Operative technique

The trocar is then unthreaded and removed. The remaining sleeve assembly is pushed again to ensure there is contact between the sleeve and the bone. (Figure 40)

Fluoroscopic control can assist if needed, to ensure that the sleeve is in direct contact with the bone.

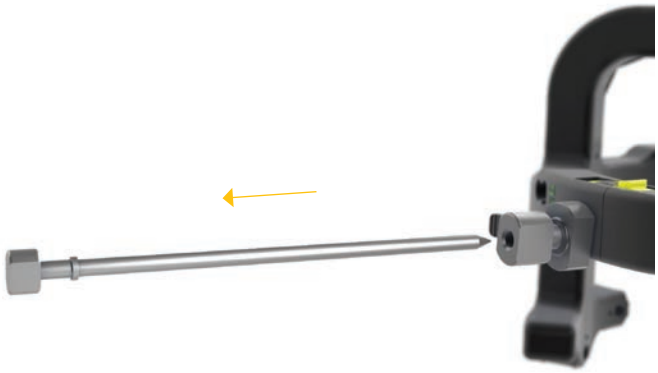


Figure 40

Note:

- **It is possible to introduce the locking lever once the sleeve/guide/trocar is in place, if desired.**
- **The locking lever is not necessarily required during the drilling phase but will prevent the sleeve from backing out during drilling.**

Operative technique

Proximal screws

Drilling of the hole and screws placement:

While ensuring the sleeve is in contact with the bone, insert the 3.5 mm diameter drill bit into the drill guide. (Figure 41)

The hole is drilled into the fragment to a depth at least two centimeters past the nail.

It is important not to penetrate the second cortex as the screw should be contained within the proximal portion of the humerus in order to prevent soft tissue damage and impingement with surrounding structures (deltoid and conjoint tendon) with rotation.

Fluoroscopic control can help define the appropriate drill depth. (Figure 42)

The screw length can be measured directly on the shaft of the drill bit or by using the depth gauge. (Figure 43)

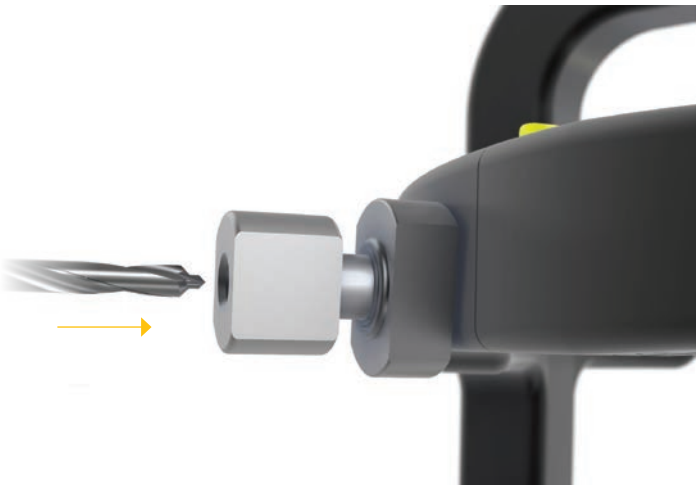


Figure 41

Figure 42

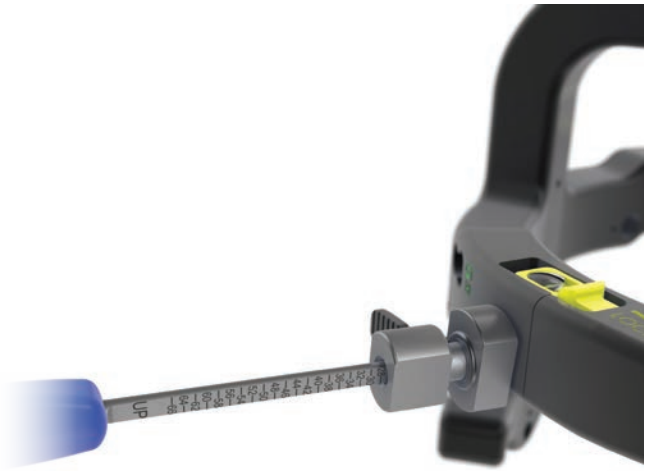


Figure 43

Note:
The proximal screws are gold.

Operative technique

The appropriate screw length is selected from the caddy and the length is verified on the screw caddy scale. (Figure 44)

Using the proximal screwdriver with the yellow handle, the screw is inserted into the sleeve and driven until the mark on the driver shaft is aligned with the edge of the sleeve. (Figure 45 & Figure 46)

These operations are repeated for the 3 additional proximal screws if needed.

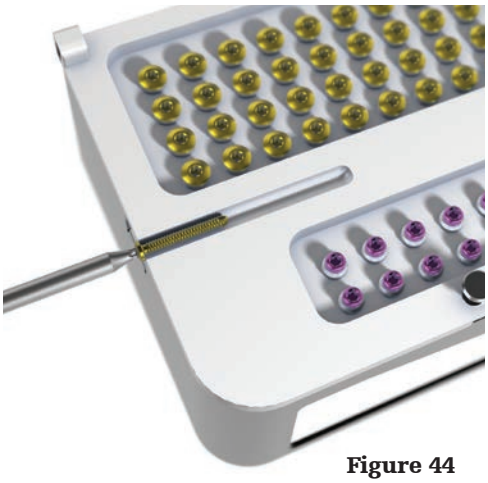


Figure 44

Figure 45

Figure 46

Operative technique

Distal screws

Drill guide/trocar assembly:

All screw positioning for distal screws follow these surgical steps:

- Drilling
- Screw measuring
- Screw placement

In order to position the distal screw, the drill guide (2), and trocar (3) are assembled and threaded together before being inserted into the jig. (Figure 47, Figure 48 & Figure 49)

Figure 47

The internal diameter of the drill guide accommodates the drill bit, screwdriver, and the distal screw.

Figure 48

The sharp tip of the trocar facilitates the advancement and positioning of the assembly against the bone.

Once assembled, it is critical to check that the two components are fully engaged in one another to ensure accuracy during the screw placement.

Figure 49

Note: The outer sleeve is not needed for distal screw placement.

Operative technique

Distal screws

Drill guide/trocar positioning:

The locking lever is first positioned into the jig, adjacent to the screw hole to be prepared.

A minimal skin incision is performed at the entry point to facilitate guide/trocar introduction into the soft tissue.

The assembly (drill guide/trocar) is introduced in the chosen holes and advanced to the bone using a twisting motion. (Figure 50)

The locking lever is depressed to allow passage of the guide/trocar assembly.

Once the tip of the trocar is against the bone, continue advancing the drill guide until the knobs are fully separated. The locking lever is then released to lock the sleeve in position.

The trocar is then unthreaded and removed and the drill guide is advanced to ensure there is contact between the sleeve and the bone.

Fluoroscopic control can be used, to ensure that the drill guide is in contact with the bone.

Figure 50

Note:

- **It is possible to introduce the locking lever once the drill guide/trocar is in place if desired.**
- **The locking lever is not necessarily required during the drilling phase but will prevent the sleeve from backing out during drilling.**

Operative technique

Distal screws

Drilling of the holes and screw placements:

Once the guide is in contact with the bone, the trocar is unscrewed and removed.

The 3.5 mm diameter drill bit is inserted into the drill guide.

The hole is drilled through the second cortical wall.

Figure 51

Fluoroscopic control can help define the appropriate depth. (Figure 51)

The screw length can be measured directly on the shaft of the bit or by using the depth gauge.

The appropriate screw length is selected from the caddy and the length is checked on the screw caddy scale.

Figure 52

Using the distal screwdriver with the purple handle, the screw is inserted into the sleeve and driven until the mark on the driver shaft is aligned with the edge of the sleeve. (Figure 52 & Figure 53)

These operations are repeated for a second distal screw if needed.

For closure of standard nail, turn directly to page 49.

Figure 53

Note:

- **The distal screws are purple**
- **The dynamic screw slot allows 6 mm of travel**

Long humeral nail

Determination of implant length

Confirm the distal position of the guide wire to ensure the wire is positioned within the distal canal at a depth where the nail will extend. (Figure 54)

Upon confirmation, position the length gauge over the guide wire. For an accurate measurement, ensure the distal end of the length gauge is in contact with the humeral head. Using the window in the length gauge, the required nail length can be read using the end of the guide wire as a reference. (Figure 55a & 55b)

If the tip of the guide wire measures between nail lengths, choose the shorter nail length in order to avoid the nail not achieving adequate depth below the articular surface.

Note:

- **The length gauge measurement accounts for 5 mm of countersinking of the nail below the articular surface.**
- **The length gauge measures the distance from the top of the nail to the tip of the nail.**
- **It is important to remember the superior distal screw hole is 35 mm from the tip to ensure the fixation extends beyond the fracture site.**

Determination of implant diameter

Canal reamers can be used intra-operatively to prepare the humeral canal and determine the best fit. Assemble canal reamers to reamer handle and pass over guide wire starting with the 6 mm reamer and progressively increase. (Figure 56) Reamers are available in 6 mm, 7 mm, 8 mm and 9 mm sizes.

- If reaming stops at 7 mm, the 7 mm nail should be chosen.
- If reaming stops at 8mm, either a 7 mm or 8 mm nail can be used.
- If required, the 9 mm reamer can be used to prepare for the 8 mm nail.

Note:
Be aware of the guide wire protruding through the reamer handle cannulation as the reamer is inserted.

Figure 54

Figure 55a

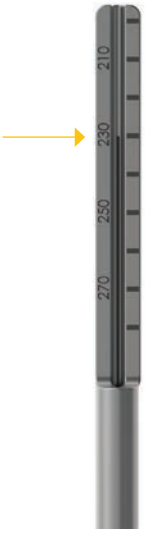


Figure 55b

Figure 56

Tornier Humeral Jig

The Tornier Humeral Jig is an external targeting device made of radio-transparent carbon fiber that allows accurate positioning of the screws in the nail. (Figure 57)

Color coding engraved marks on the jig identifies the location of each screw (blue for the left nail and green for the right nail, white for common screws working for both sides).

Figure 57

On the proximal part of the jig (Figure 58)

- GT HI for the highest and anterior greater tuberosity screw
- GT LO for the lowest and posterior greater tuberosity screw
- LT for the lesser tuberosity screw
- CTR for the calcar support screw

Figure 58

On the distal part of the jig (Figure 59)

- Used for the standard humeral nail only
- Not used for targeting distal holes of the long nail
- Positioned on the lateral side of the humerus

Figure 59

Note:
An outrigger connection must be assembled if the screw for the lesser tuberosity is needed.

Long nail outrigger connection

A long nail outrigger connection is assembled for the lesser tuberosity and targeting of the distal screws.

In order to connect the long nail outrigger to the jig, the appropriate outrigger should be chosen (left for a left shoulder and right for a right shoulder). (Figure 60)

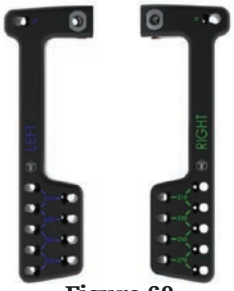


Figure 60

The extension is then connected to the jig by sliding it down in the groove of the jig. (Figure 61)

Figure 61

Once the extension is in place, the connection is secured by two mechanisms. First, the yellow locking clip is slid over the connection. (Figure 62)

Figure 62

Second, the clamp screw is tightened with the 12 mm wrench to secure the assembly. (Figure 63a & 63b)

Figure 63a

After tightening the clamp screw, ensure the long outrigger is firmly secured to the jig.

Figure 63b

Note:
Clamp screw must be secured tightly to ensure accurate targeting of distal screws.

Jig/long humeral nail assembly

Assembly of the connection bolt and the jig

The connection bolt is inserted into the sleeve of the jig. (Figure 64)

Figure 64

Assembly of the Tornier Long Humeral Nail with the jig

The long humeral nail can be assembled in only one position relative to the jig.

In order to assemble the Tornier Long Humeral Nail into the bolt, rotate the tip of the nail until the proximal end of the nail fits into the connector. (Figure 65)

The bolt is then threaded into the humeral nail to lock the nail in the proper position. (Figure 66)

The bolt is then tightened with the 12 mm wrench (Figure 67)

Figure 65

Figure 66

Figure 67

Note:

- **Once the nail is properly assembled, a visual check will confirm alignment between the nail and targeting jig holes.**
- **Improper assembly or tightening can compromise the precision of the jig during drilling or insertion of locking screws.**

Nail insertion and height adjustment

Nail insertion:

The Tornier Long Humeral Nail is manually inserted onto the guide wire, using gentle rotations to facilitate its progress through the soft tissue.(Figure 68, Figure 69, & Figure 70)

It is critical to not place excessive force on the nail to prevent fragment displacement.

Note:
Do not mallet on the jig.

Height adjustment:

It is critical to fully bury the Tornier Long Humeral Nail below the humeral head to prevent any cuff impingement between the superior cuff and the top of the nail.

There are two methods to identify the proper nail depth:

- A groove on the jig connector can be seen under fluoroscopic control which allows the depth of the nail to be verified, even when using the percutaneous approach. (Figure 71) The groove is located 5 mm above the top of the nail, and should be inserted into the humeral head at this depth to avoid leaving the humeral nail proud. (Figure 72).
- It is also possible to insert the 3 mm marker wire into the jig to intra-operatively identify the highest point of the nail (see page 22 for image).

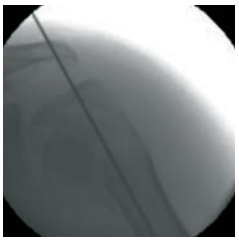


Figure 68

Figure 69

Figure 70

Figure 71

Figure 72

Note:
It is critical to check several views when working under fluoroscopic control to ensure the top of the humeral nail is fully buried into the humeral head.

Nail insertion and version adjustment

To restore the anatomic version of the tuberosities and humeral head, a retroversion rod can be assembled to the jig. The retroversion rod is an assembly consisting of the following components (Figure 73):

- 2 rods
- Wrist cradle

Figure 73

The version rod is set at 20° of retroversion relative to the forearm and provides a useful landmark in procedures involving comminutive fractures where all anatomical landmarks have disappeared.

Nail insertion and version adjustment

Assembly of the version rod:

The two version rods are assembled to another so one is in the vertical plane and one in the horizontal plane. (Figure 74)

The wrist cradle is then screwed onto the threaded end of the rod. (Figure 75)

The version rod assembly is inserted into the jig through a hole located at the end of the jig making sure that the flat on the rod is facing medial. (Figure 76)

The version rod provides a version landmark of 20° from the forearm.

Figure 74

Figure 75

Figure 76

Note:
To avoid rotational malposition of the nail, two additional verifications can be performed.

First, the **arm should be held in neutral rotation** during screw fixation, especially when the proximal segment is reduced first, followed by distal interlocking fixation.

The second is to **verify the position of the fourth proximal screw cannula**, which is designed to face the axis of the humeral head. This cannula can be placed into the jig (but not through the skin) to give the surgeon a general measure of the nail's retroversion. Using fluoroscopy in a true anteroposterior position, this fourth screw guide should be positioned with thirty degrees of retroversion (just like the average retroversion of the humeral head).

Guide wire removal

Once the nail is inserted, it is necessary to remove the guide wire before drilling the screw holes. (Figure 77)

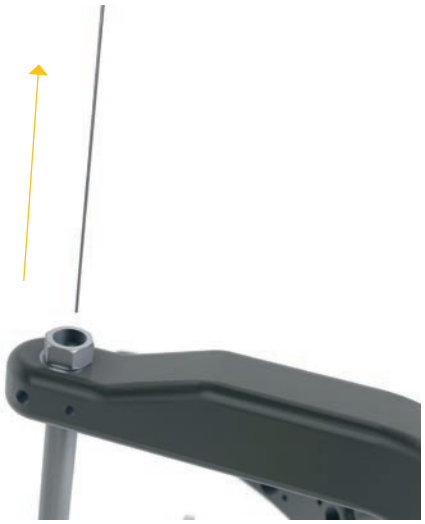


Figure 77

Implantation of the screws

The Tornier Humeral Long Nail can accommodate 4 proximal screws:

- 2 Greater tuberosity screws
- 1 Lesser tuberosity screw
- 1 Calcar screw

and 3 distal screws:

- 2 static anterior to posterior screws
- 1 static offset screw

All screws have hexalobe head connection. (Figure 78)

Figure 78

Note:
The number of screws needed varies and is case specific depending on the type of fracture and surgeon preference.

Proximal screws

Drill sleeve/drill guide/trocar assembly:

All screw positioning for the proximal screws follow these surgical steps:

- Drilling
- Screw measuring
- Screw placement

In order to position proximal screws, the screw sleeve (1), drill guide (2), and trocar (3) are assembled and threaded together before being inserted into the jig. (Figure 79)

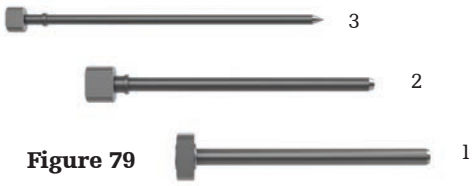


Figure 79

All three components are inserted over one another and screwed together. (Figure 80 & Figure 81)

Figure 80

The internal diameter of the screw sleeve has the same diameter as the proximal screwdriver shaft and the head of the proximal screw to allow for guided screw insertion.

The internal diameter of the drill guide has the same diameter as the drill bit shaft and the distal screw head to provide guided preparation of the screw holes.

The sharp tip of the trocar facilitates the advancement and positioning of the assembly against the bone.

Once assembled, it is critical to check that the 3 components are fully engaged with one another to ensure accuracy during screw placement.

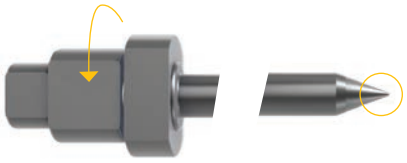


Figure 81

Proximal screws

Drill sleeve/drill guide/trocar positioning:

The locking lever is first positioned into the jig, adjacent to the screw hole to be prepared. (Figure 82)

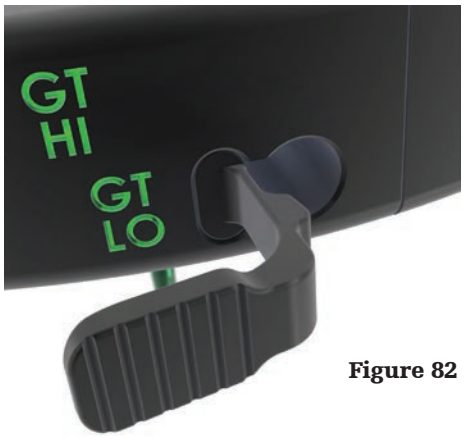


Figure 82

A minimal skin incision is performed at the entry point to facilitate sleeve/guide introduction into the soft tissue.

The assembly (sleeve/guide/trocar) is introduced in the chosen holes and advanced to the bone using a twisting motion. (Figure 83a)

The locking lever is depressed at insertion to allow passage of the sleeve/guide trocar assembly.

Once the tip of the trocar is against the bone, continued advancement of the screw sleeve and drill guide is performed until the knobs are fully separated as shown. (Figure 83b)

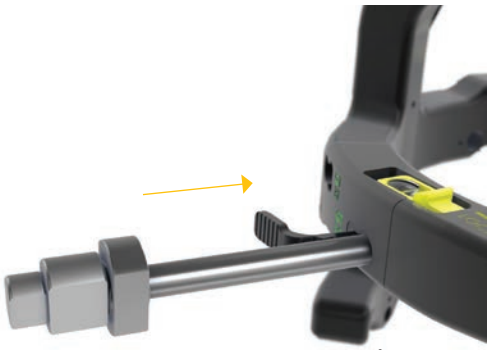


Figure 83a

The locking lever is then released to lock the sleeve in position.

The trocar is then unthreaded and removed. The remaining sleeve assembly is pushed again to ensure there is contact between the sleeve and the bone. (Figure 84)

Fluoroscopic control can assist if needed, to ensure that the sleeve is in direct contact with the bone.

Figure 83b

Note:

- **It is possible to introduce the locking lever once the sleeve/guide/trocar is in place, if desired.**
- **The locking lever is not necessarily required during the drilling phase but will prevent the sleeve from backing out during drilling.**

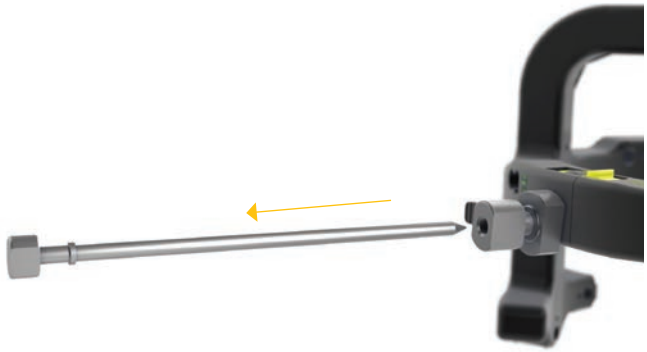


Figure 84

Proximal screws

Drilling of the hole and screws placement:

While ensuring the sleeve is in contact with the bone, insert the 3.5 mm diameter drill bit into the drill guide. (Figure 85)

The hole is drilled into the fragment to a depth at least two centimeters past the nail.

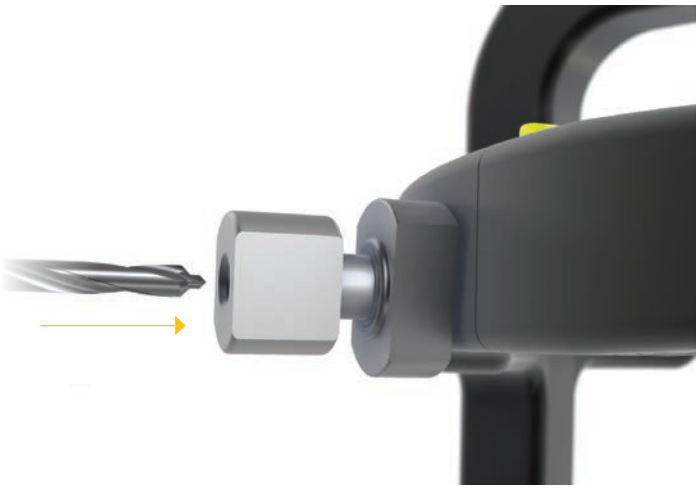


Figure 85

It is important not to penetrate the second cortex as the screw should be contained within the proximal portion of the humerus in order to prevent soft tissue damage and impingement with surrounding structures (deltoid and conjoint tendon) with rotation.

Fluoroscopic control can help define the appropriate drill depth. (Figure 86)

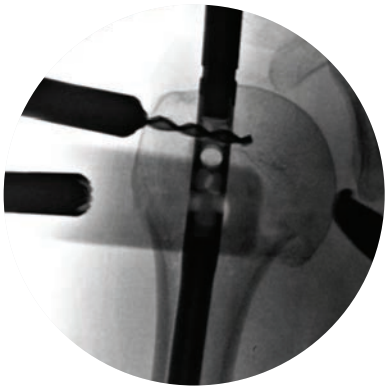


Figure 86

The screw length can be measured directly on the shaft of the drill bit or by using the depth gauge. (Figure 87)

Figure 87

Note:
The proximal screws are gold.

The appropriate screw length is selected from the caddy and the length is verified on the screw caddy scale. (Figure 88)

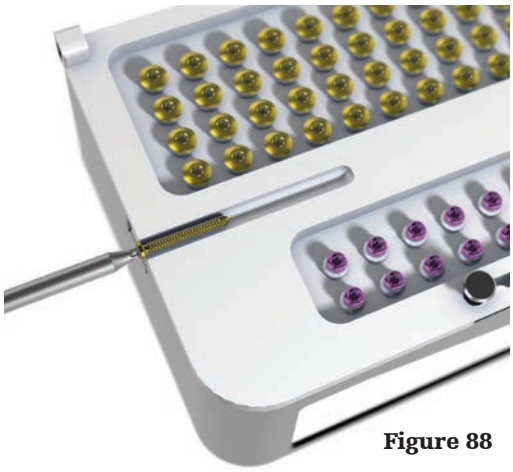


Figure 88

Using the proximal screwdriver with the yellow handle, the screw is inserted into the sleeve and driven until the mark on the driver shaft is aligned with the edge of the sleeve. (Figure 89 & Figure 90)

These operations are repeated for the 3 additional proximal screws if needed.

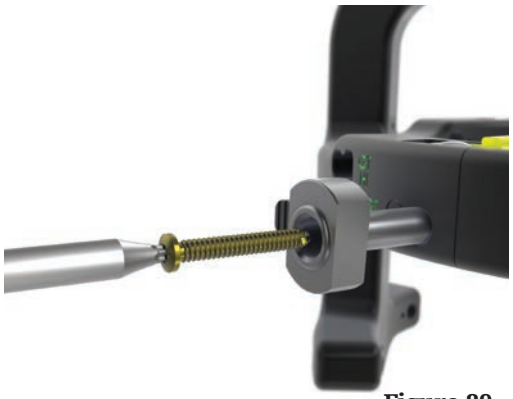


Figure 89

Figure 90

Distal screws

Drill guide/trocar assembly:

All screw positioning for distal screws follow these surgical steps:

- Drilling
- Screw measuring
- Screw placement

Figure 91

In order to position the distal screw, the drill guide (2), and trocar (3) are assembled and threaded together before being inserted into the jig. (Figure 91, Figure 92 & Figure 93)

Figure 92

The internal diameter of the drill guide accommodates the drill bit, screwdriver, and the distal screw.

The sharp tip of the trocar facilitates the advancement and positioning of the assembly against the bone.

Once assembled, it is critical to check that the two components are fully engaged in one another to ensure accuracy during the screw placement.

Figure 93

Note:
The outer sleeve is not needed for distal screw placement.

Distal screws

Drill guide/trocar positioning:

The locking lever is first positioned into the jig, adjacent to the screw hole to be prepared.

A minimal skin incision is performed at the entry point to facilitate guide/trocar introduction into the soft tissue.

The assembly (drill guide/trocar), based on nail length, is introduced in the chosen hole and advanced to the bone using a twisting motion. (Figure 94)

Figure 94

The locking lever is depressed to allow passage of the guide/trocar assembly.

Once the tip of the trocar is against the bone, continue advancing the drill guide until the knobs are fully separated. The locking lever is then released to lock the sleeve in position.

The trocar is then unthreaded and removed and the drill guide is advanced to ensure there is contact between the sleeve and the bone.

Fluoroscopic control can be used to ensure that the drill guide is in contact with the bone.

Note:
For each long nail length, there are two anterior posterior screws and one 20º offset screw.

Distal screws

Drilling of the holes and screw placements:

Once the guide is in contact with the bone, the trocar is unscrewed and removed.

The 3.5 mm diameter drill bit is inserted into the drill guide. (Figure 95)

It is critical to ensure minimal force is used when drilling the distal screw holes. Let the drill bit engage into the bone to ensure skiving does not occur off the distal humerus.

The hole is drilled through the second cortical wall. Fluoroscopic control can help define the appropriate depth.

Figure 95

Note:
If your surgeon has determined multiple distal screws will be used, it is recommended to leave the first drill bit engaged in the bone while a second drill bit is opened and drilled into the second distal screw hole. Doing this will help to ensure the construct is stable and accurate targeting of multiple distal screws will occur.

The screw length can be measured directly on the shaft of the bit or by using the depth gauge.

The appropriate screw length is selected from the caddy and the length is checked on the screw caddy scale.

Using the distal screwdriver with the purple handle, the screw is inserted into the sleeve and driven until the mark on the driver shaft is aligned with the edge of the sleeve. (Figure 96)

These operations are repeated for the second or third distal screw if needed.

Figure 96

Note:
If there is any concern over injury to a nerve or soft tissue an open technique can be used to gain direct visualization to the soft tissue structures and bone for the insertion of the drill bit and distal screws. For the open technique, an incision of 2-3 cm shall be made. Place retractors in, then slide the drill guide/trocar assembly into the wound and continue normal drilling and screw targeting.

Closing

Once all bone fragments are secured to the nail, the jig is removed using the 12 mm wrench. (Figure 97)

Figure 97

The connection bolt and the jig are removed. (Figure 98)

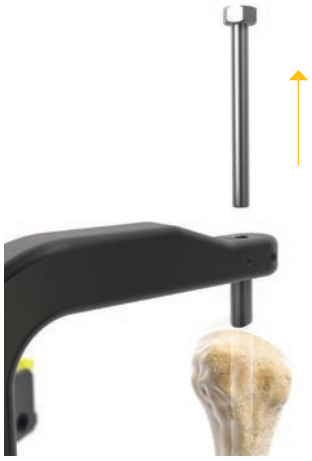


Figure 98

Fluoroscopic control can assist in checking the stability of the assembly and verifying the locations of the fragments. (Figure 99)

The soft tissue is then closed per surgeon preference.

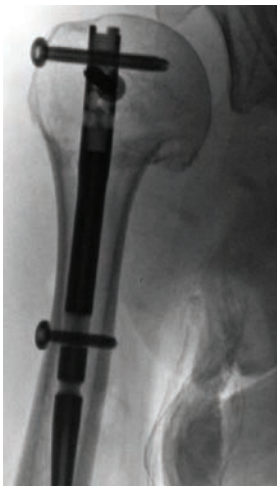


Figure 99

Removal of the Tornier Humeral Nail

If a revision of the Tornier Humeral Nail is necessary, the use of a c-arm is strongly recommended to locate the top of the nail.

The jig is introduced to the level of the nail and secured before attempting removal of any screws. (Figure 100)

Figure 100

The jig is assembled to the top of the nail using the 12 mm wrench.

All screws are removed using the proximal and distal screwdrivers provided in the instrument set. (Figure 101)

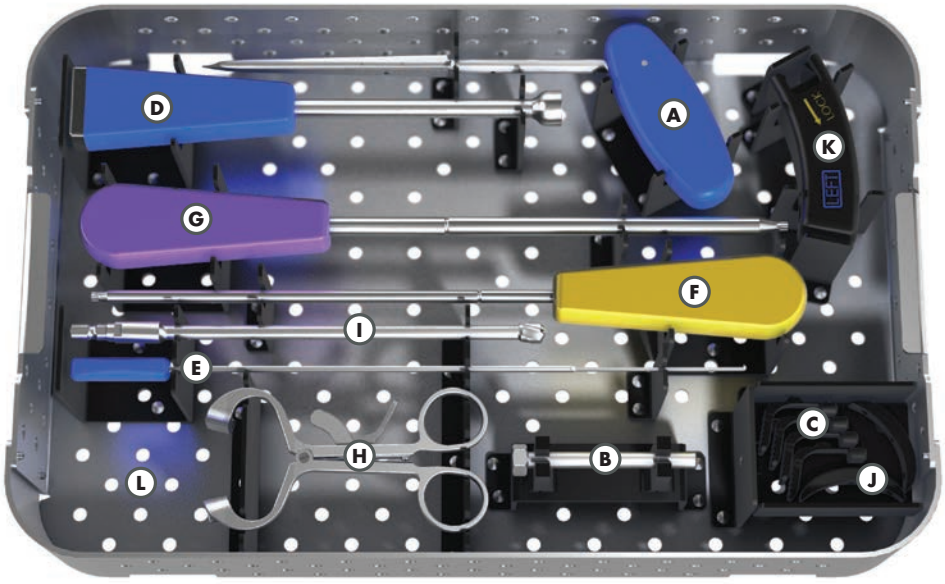
Ensure that all screws have been removed using fluoroscopy.

Figure 101

If preferred, the slaphammer can be attached to the connection bolt and used to remove the device. (Figure 102)

Figure 102

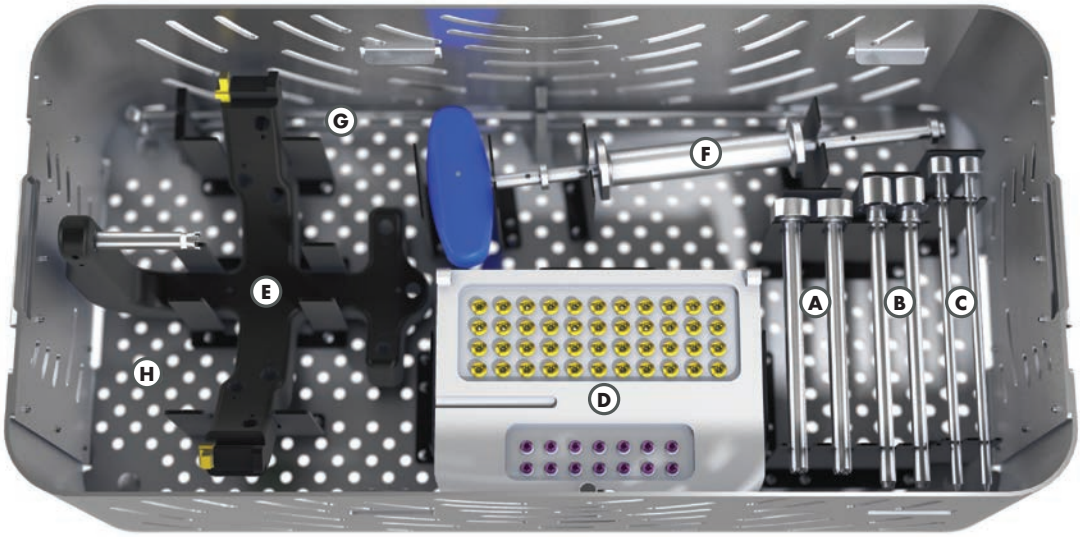
Instrumentation: 9020000



Humeral nail set: removable upper tray

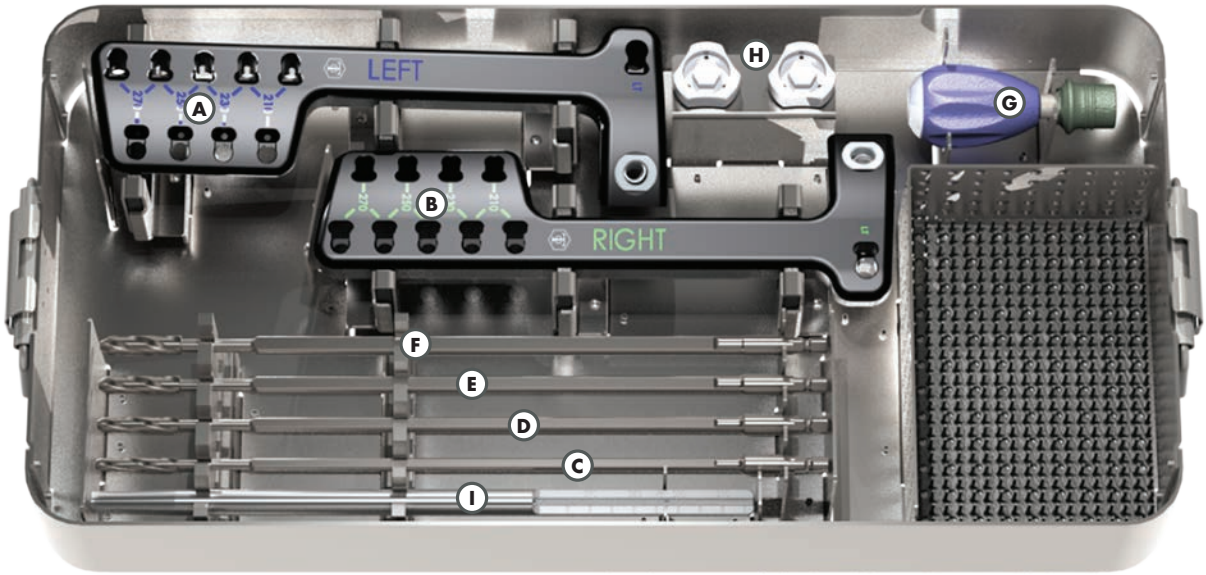
#	Reference	Description
A	9020010	Starter awl
B	9020070	Connection bolt
C	SH93759	Locking lever (qty 2)
D	9020080	12 mm Wrench
E	9020150	Depth gauge
F	9020170	Proximal screwdriver
G	9020171	Distal screwdriver
H	9020202	Cuff spreader
I	9020050	Humeral reamer
J	9020091	Version rod cradle
K	9820063	Jig outrigger
L	9020004	Case upper tray

Instrumentation



Humeral nail set: bottom tray

#	Reference	Description
A	9020110	Nail screw sleeve (qty 2)
B	9020120	Nail drill guide (qty 2)
C	9020130	Trochar (qty 2)
D	9020002	Case screw caddy
E	9020060 or AHN0337	Targeting jig
F	9020200	Slaphammer
G	9020090	Version rod (qty 2)
H	9020004	Case upper tray



Long humeral nail set

#	Reference	Description
A	DHN5803	Long nail jig outrigger, left
B	DHN5810	Long nail jig outrigger, right
C	DHN5804	Long nail reamer, 6mm
D	DHN5805	Long nail reamer, 7mm
E	DHN5806	Long nail reamer, 8mm
F	DHN5807	Long nail reamer, 9mm
G	DHN5808	Long nail reamer handle
H	DHN5809	Long nail jig outrigger clamp screw
I	DHN5811	Long nail length gauge
J	DHN5813	Long nail case base
K	DHN5814	Long nail case lid

Implants

Implants & single use instruments

Sterile Tornier Humeral Nail

Reference	Description	Length
0020500	Humeral nail right	130
0020600	Tornier nail: blue	130
DHN5795	Left, diam 7 mm	210
DHN5796	Left, diam 7 mm	230
DHN5797	Left, diam 7 mm	250
DHN5798	Left, diam 7 mm	270
DHN5799	Left, diam 8 mm	210
DHN5800	Left, diam 8 mm	230
DHN5801	Left, diam 8 mm	250
DHN5802	Left, diam 8 mm	270
DHN5787	Right, diam 7 mm	210
DHN5788	Right, diam 7 mm	230
DHN5789	Right, diam 7 mm	250
DHN5790	Right, diam 7 mm	270
DHN5791	Right, diam 8 mm	210
DHN5792	Right, diam 8 mm	230
DHN5793	Right, diam 8 mm	250
DHN5794	Right, diam 8 mm	270

Non sterile proximal cannulated screws

Reference	Description	Length
7425028	Cannulated proximal screw dia 5 mm: gold	28 mm
7425032	Cannulated proximal screw dia 5 mm: gold	32 mm
7425036	Cannulated proximal screw dia 5 mm: gold	36 mm
7425040	Cannulated proximal screw dia 5 mm: gold	40 mm
7425044	Cannulated proximal screw dia 5 mm: gold	44 mm
7425048	Cannulated proximal screw dia 5 mm: gold	48 mm
7425052	Cannulated proximal screw dia 5 mm: gold	52 mm
7425056	Cannulated proximal screw dia 5 mm: gold	56 mm

Non sterile distal screws

Reference	Description	Length
7424520	Distal screw dia 4.3 mm: purple	20 mm
7424522	Distal screw dia 4.3 mm: purple	22 mm
7424524	Distal screw dia 4.3 mm: purple	24 mm
7424526	Distal screw dia 4.3 mm: purple	26 mm
7424528	Distal screw dia 4.3 mm: purple	28 mm
7424530	Distal screw dia 4.3 mm: purple	30 mm
7424532	Distal screw dia 4.3 mm: purple	32 mm

Sterile single use instruments

Reference	Description	Length
7020140	3 mm drill bit	200 mm
7020100	Marker wire	150 mm
7020030	Guide wire	500 mm

Notes

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AP-011617 12-2021

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