The Orthofix Tibial Nailing System

By W.C. Oppenheim, MD
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Insertion Site
Two entry points are possible: superior or anterior.

Superior Approach
The preferred entry point is the superior approach, since it allows easier alignment with the medullary canal.

Anterior Approach
When this approach is used, the entry portal must be very proximal, no more than 1 cm distal to the anterior edge of the tibial plateau. A more distal entry point may result in damage to the posterior cortex.

Reamed Nail
Insert guide wire with olive until its tip sits 0.5-1 cm proximal to the ankle joint, taking care to ensure that it is exactly in the midline.

Ream to a width 1-2 mm greater than the proposed nail.
Insert the Plastic Guide Wire Exchange Tube over the guide wire with olive to a point well beyond the fracture site. Replace the guide wire with olive with a plain 3 mm guide wire. Confirm that the tip of the plain guide wire is in the correct position and remove the Plastic Exchange Tube.

**Nail Insertion: Reamed or Unreamed Nail**

Insert the Locking Rod into the back of the handle and the nail of correct diameter and length into the nail support, and tighten the locking rod with the 5 mm Allen wrench.

Insert the nail, if reamed over the guide wire, as far as possible using image intensification. Remove guide wire, if applicable, when its exit point from the nail is at the level of the entry portal. The nail is correctly inserted when the step of the nail support is flush with the surface of the bone.

The Sliding Hammer, attached to the end of the nail locking rod and fully tightened, may be used to insert the nail gently in the correct position. Check that the locking rod is tight after hammer removed.
Distal Locking

Insert the guide bar into the handle, adjust its position until the number corresponding to the selected nail length lines up with the front of the handle. Lock the guide bar firmly into place.

Mount the distal outrigger on the guide bar so that it lies on the correct side of the tibia, usually medial. Insert the screw guides into the outrigger. No incision is made yet.

Insert a drill guide into one of the two holes in the guide bar proximal to the distal outrigger. Make an incision and advance the drill guide until its teeth are engaged in the tibia and stabilized on the center of the tibial crest. A 4 mm drill bit is used to drill the anterior cortex only.

Clear the hole in the bone with the 4 mm T-handled Reamer until the reamer can be heard tapping the nail.
Remove the 4 mm T-handled Reamer and insert the T-handled Stabilizing Rod, down to the nail, again tapping the nail to ensure contact.

Attach the correct Stabilizing Spacer for the diameter of the nail to the T-handled Stabilizing Rod. Position the Spacer so that the correct nail diameter is visible on the upper surface, facing towards the surgeon.

Maintain contact between the tip of the Stabilizing Rod and the nail. The stabilizing rod may have to be lifted up or pushed down to establish correct contact with the nail. Make an incision beneath each screw guide. Advance the screw guides until they are in contact with the cortex. Tighten the clamp locking nut on the outrigger to hold them firmly in place. Insert the 4 mm drill guide into the most distal of the screw guides and drill the bone with the 4 mm drill bit. While the surgeon is drilling, the assistant must hold the T-handle of the Stabilizing Rod, keep its tip against the nail, and maintain this position throughout the drilling procedure.

Remove the drill bit and drill guide, and insert the graduated angled trocar. Drill the second hole in the same way.
Insert the locking screws of correct length. Remove the distal outrigger and the T-handled stabilizing rod.

**Check for Fracture Distraction**

Check for any malrotation or distraction of the fracture site, before carrying out proximal locking. If the fracture site is distracted, attach the sliding hammer to the locking rod and close the fracture gap by gentle reverse hammering.

**Proximal Locking**

Loosen the guide bar locking screw and move the guide bar until the P mark is level with the front surface of the handle. Lock the bar into position.

Mount the proximal outrigger on the guide bar and insert two screw guides into the holes in the proximal outrigger. Make an incision and advance the screw guides down to the cortex. Lock them into position with the clamp locking nuts.
The medial hole is drilled first. Insert the 4 mm drill guide into the screw guide and drill the bone with the 4 mm drill bit. After drilling, remove the drill bit and drill guide, and insert the graduated angled trocar. Drill the lateral hole and insert the locking screws of correct length.

Removal of the Jig Assembly

Remove the proximal outrigger and the guide bar. Before removing the handle from the nail, check correct insertion of locking screws both in AP and lateral planes. Remove the locking rod and the handle.

Insert the nail end cap.
Intramedullary nailing has become increasingly popular as a treatment for tibial fractures, and it is suitable for all fractures extending from 7-8 cm distal to the tibial plateau, to within 5.5 cm of the distal articular surface, provided that the epiphyses are closed. Some experienced surgeons are now reporting the use of unreamed tibial nails in open fractures as severe as Gustilo grades IIIb and IIIC. The Orthofix Intramedullary Fixation System is a set of intramedullary nails which offers several advantages over existing systems. A major advantage of the system is the ability to insert both proximal and distal locking screws accurately and quickly without the use of X-rays, using an external mechanical targeting device. The locking screws have a self-tapping thread which engages the proximal cortex only. The remainder of the screw has a smooth shank 4 mm in diameter which penetrates the distal cortex. A locking screw of this configuration is much stronger for a given diameter than a fully threaded screw. The locking holes in the nail are 4.1 mm wide. The system provides secure proximal and distal locking, ensuring maximal stability, with minimal risk of screw breakage.

Reamed or Unreamed Nails?

This is ultimately a matter of surgeon preference, but an unreamed nail is strong enough to support a stable tibial fracture in most cases, and will cause much less damage to the bone vasculature. An unreamed nail is therefore recommended for all fractures where the external blood supply of the tibia has been disturbed. These include most open fractures, and closed fractures with soft tissue damage of Tscherne types C II and C III. The usual diameter for an unreamed nail is 9 mm, but an 8 mm nail may be needed for smaller diameter bones. Sizes above 9 mm will nearly always require some reaming. The position and stability of the fracture is also relevant: an unstable fracture, or a fracture in the metaphyseal area, may need a larger nail for adequate stabilization, and would therefore need to be reamed. In open fractures, however, reaming is contraindicated.

Cautions

1. While the approach to the entry point may be made with a bloodless field, it has been suggested that reaming and nail insertion should not be performed in the tibia in the presence of a tourniquet, since this may lead to necrosis of the muscles and/or compartment syndrome.

2. Fracture distraction may be a potent cause of compartment syndrome in tibial fractures, and may also be a factor in the development of delayed union. Distraction for any time should therefore be avoided during the operation, and tibial fractures should never be locked in distraction. The method of avoiding this is described in the technique.

BIBLIOGRAPHY

PRE-OPERATIVE ESTIMATION OF NAIL AND LOCKING SCREW SIZE

The surgeon should be able to gain a good estimate of the required length pre-operatively, by direct measurement of the length of the tibia from the plateau to the medial malleolus, if necessary, using the uninjured leg. The X-ray Overlay (PT200A or PT250A) may also be used by placing it over the radiograph, or over films of the uninjured tibia in the case of comminuted fractures, to establish the likely length of the nail and the locking screws. It should be noted that the X-ray Overlay is supplied to allow for X-ray magnification of 8% or 15%. By looking at the width of the medullary canal on the radiograph, and from a knowledge of the weight of the patient and the severity of the fracture, the surgeon will be able to gauge the likely diameter of the nail, and whether to use a reamed or an unreamed nail. A larger nail is indicated in severely comminuted diaphyseal fractures and in proximal third fractures to provide extra stability. In general, the size of nail chosen will depend on the size of the bone, and the amount of reaming, if any, that the surgeon is prepared to accept.
General surgical instrumentation for open limb surgery, including tissue retractors of various sizes, should be available.

**GENERAL NAILING EQUIPMENT (not provided)**
Cannulated Drill, with Adapter for Reaming Drive Shaft Attachment

**GENERAL NAILING EQUIPMENT**
- 3.0 mm Guide Wire with Olive; length 980 mm
- 3.0 mm Guide Wire without Olive; length 980 mm
- 3.0 mm Guide Wire without Olive; length 480 mm
- 2.0 mm Kirschner Wire without Olive; length 150 mm
- Soft Tissue Protector (not illustrated)
- T-Handle for Guide Wire
- Slotted Hammer
- Reamers (8-15 mm) with integral flexible drive shaft (not illustrated)
- 3.0 mm Guide Wire without Olive; length 480 mm
- 3.0 mm Guide Wire without Olive; length 980 mm

**ORTHOFIX GENERAL INSTRUMENTATION**
Common to Femoral and Tibial Nailing Systems
- 1 Sterilization Box for Orthofix General Instrumentation, empty
- 1 Sliding Hammer with detachable swing arm
- 1 T-Handled Locking Screw Extractor
- 1 Screw Adapter, Femur
- 1 Screw Adapter, Tibia
- 1 Black Handle with bayonet fitting
- 1 Spanner 13 mm
- 1 Pointed Awl
- 1 Rigid Reamer 7 mm; length 410 mm
- 1 Rigid Reamer 8 mm; length 410 mm
- 1 Rigid Reamer 9 mm; length 410 mm
- 1 Locking Screw Depth Gauge
- 1 Plastic Guide Wire Exchange Tube

Reamer Sterilisation Box, empty
### ORTHOFIX SPECIFIC INSTRUMENTATION
For Tibial Nailing Systems only

1. Sterilization Box for Orthofix Specific Instrumentation, **empty** ........................................... 17406
2. External Jig for locking procedure, consisting of:
   - 1 Nail Support Handle with Bar Locking Screw ............................................................. 17410
   - 1 Locking Rod ......................................................................................................................... 17430
   - 1 Guide Bar ............................................................................................................................ 17420
   - 1 Proximal Outrigger ............................................................................................................ 17440
   - 1 Distal Outrigger .................................................................................................................. 17450
3. Allen Wrench 5 mm .................................................................................................................... 30017
4. T-Handled Stabilizing Rod 4 mm ............................................................................................... 17481
5. T-Handled Hand Reamer 4 mm ................................................................................................. 17426
6. U-Shaped Stabilizing Spacer 8 / 13 mm .................................................................................... 17482
7. U-Shaped Stabilizing Spacer 9 / 12 mm .................................................................................... 17483
8. U-Shaped Stabilizing Spacer 10 / 11 mm ................................................................................. 17484
9. Tibial Sound 8 mm diameter; length 440 mm (not illustrated) .................................................. 17475
10. Tibial Sound 9 mm diameter; length 440 mm (not illustrated) ................................................ 17476
11. Strike Plate (not illustrated) ..................................................................................................... 17477

1. Tibial Nail and Locking Screw X-ray Overlay 8% .................................................................. PT200A
2. Tibial Nail and Locking Screw X-ray Overlay 15% ................................................................. PT250A
NAILS AND NAIL END CAPS

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Nail End Cap

It should be noted that only the nails shown in the unshaded area are the standard issue range. Nails in the shaded area are available on special order where a code number is shown, but will not be supplied unless specifically requested. The 8 mm and 9 mm nails are solid. The diameter of the 8 mm nail is 9 mm for the proximal 80 mm for added strength. Sizes from 10 mm upwards, which are normally inserted after reaming, have a 4 mm cannulation, suitable for a plain 3 mm guide wire.

1 Sterilization Box for 8 and 9 mm nails, locking screws and nail end caps, empty ................................................. 17407
1 Sterilization Box for 10 and 11 mm nails, locking screws and nail end caps, empty .................................................. 17408

LOCKING SCREWS AND REVISION LOCKING SCREWS

Tibial Nail Locking Screws
Thread Ø 6 mm

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Revision Locking Screws
Thread Ø 8 mm

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Sterilization Box for locking screws and revision locking screws

Empty .............................................................................................................................. 17404

Note: Revision locking screws are available for use in situations where the thread of a standard screw does not have sufficient purchase for any reason, e.g. in osteoporotic bone.

*Note that the longer locking screws, which will be used in the metaphysis, have a longer thread length.*
CLEANING AND MAINTENANCE OF EQUIPMENT

The implants and instrumentation should be removed from their packaging and cleaned thoroughly using medical grade alcohol 70% + distilled water 30% (Detergents with free fluoride, chloride, bromide, iodide or hydroxyl ions must not be used, as they will damage the black anodised coating on any Orthofix products). After cleaning, the devices should be rinsed with sterile distilled water and dried using clean non-woven fabric.

The Nail Support Handle (17410) should not be dismantled, but should be cleaned and sterilized as one piece.

The Sliding Hammer (17392) comes apart for cleaning: the wing nut on the end of the bar has a reverse thread, and should be turned clockwise to remove it. The hammer can then be slid off, and the central lumen can be cleaned. The hammer should then be reassembled before sterilization.

Particular attention should be paid to cleaning the threaded hole at the end of the Locking Rod (17430), and the holes in the Guide Bar (17420).

STERILIZATION

Prior to surgical use, the products should be cleaned as described above and sterilized by steam autoclaving following a validated sterilization procedure, utilizing a prevacuum cycle (Orthofix recommends the following cycle: steam autoclave 132°-135°C [270°-275°F], minimum holding time 10 minutes). All locking screws should be left untightened during sterilization.

THE NAILS, NAIL END CAPS AND BONE LOCKING SCREWS SHOULD NEVER BE REUSED

These implants may look “as new” when removed, but will have been subjected to considerable stresses while in the patient, and their fatigue life is not sufficient for second usage.
OPERATIVE TECHNIQUE

PREPARATION OF THE PATIENT

The patient is placed supine on an operating table or fracture table, either with the knee flexed and the affected leg hanging vertically down, or with the knee flexed over a padded bar, taking care to avoid any pressure on the fibular head (common peroneal nerve). In cases where reduction cannot be achieved with the leg in this position, traction is exerted through a Steinmann-type pin inserted through the os calcis, with the flexed knee placed over a padded bar, which acts as counter-traction. Skeletal traction is particularly recommended for distal fractures, in order to achieve good control of alignment. The leg is then cleaned and sterilized from mid-thigh to toes, and draped separately. If skeletal traction is being used, care should be taken to exclude the traction pin from the operating field.

INSERTION SITE

A 5 cm vertical skin incision is made in the midline, centred at the level of the tibial plateau, and extended down to the deep fascia. The skin and subcutaneous tissues are reflected medially until the medial border of the patellar tendon is visible. An incision is then made medial to the tendon, proximal to the tibial tuberosity. The tendon is retracted laterally, and the midpoint of the anterior margin of the tibial plateau identified. Two entry points are possible: superior or anterior, the preferred one being the superior approach, since it allows easier alignment with the medullary canal.

Superior Approach

The advantages of this approach are that the superficial infrapatellar structures are undisturbed, which may reduce the risk of post-operative knee pain, and that the entry portal is more directly in line with the medullary canal. The anterior margin of the tibial plateau is palpated, and the pad of fat in the midline gently pushed posteriorly. This action exposes the surface of the plateau anterior to the insertion of the anterior cruciate ligament. The tip of the Pointed Awl (17470) is placed 8-10 mm posterior to the edge of the plateau, and the Image Intensifier used to confirm that this is centered over the canal. If it is not, it is adjusted until it is satisfactory, checking the position of the tip of the awl in the medio-lateral plane. The awl is then advanced with a rotational action towards the medullary cavity, keeping the straight part of the handle parallel with the tibial diaphysis, so that the tip of the awl is pointing directly down the tibial shaft.
The awl is removed, and at this point it is useful to confirm that the medullary canal has been opened, using the 7 mm Rigid Reamer (17472), which is gently pushed down into the medullary canal. The introduction of the Rigid Reamer should be stopped as soon as resistance is felt. With the Rigid Reamer in place, the Image Intensifier should now be used to confirm alignment in both planes. Alternatively, a 4 mm Steinmann pin can be used in the same way. The entry portal is opened to 9 mm with the larger rigid reamers, and is now ready for the insertion of an unreamed nail, or for a guide wire prior to reaming, as described below.

It should be emphasized that the Rigid Reamers are not designed to ream cortical bone, and no attempt should be made to ream the isthmus with these instruments.

If the central part of the medullary canal is not wide enough, power reamers should be used to enlarge it as necessary, as described on page 10.
Anterior Approach

Because the nail is relatively rigid, an anterior entry portal must be very proximal, no more than 1 cm distal to the anterior edge of the tibial plateau. A more distal entry point may result in damage to the posterior cortex.

The awl is used to open the medullary canal in the midline, again taking care to keep the straight part of the shaft of the awl parallel to the long axis of the tibial shaft. An early check should be made with the Image Intensifier in both the sagittal and frontal planes to confirm that the tip of the awl is in the line of the tibial canal. It is much harder to alter the entry portal once it has been fully established.

The 7 mm Rigid Reamer should be used to reach the medullary canal, and to confirm the alignment as described on page 8. The larger Rigid Reamers should be used to enlarge the metaphyseal entry portal to 9 mm, but, as stated before, they should not be used to ream the cortical bone. If the isthmus is not wide enough for the proposed nail, power reamers should be used, as described on page 10. Because of the oblique nature of the entry portal where the anterior approach is used, the center of the final hole will be midway between the tibial plateau and the tuberosity. A high starting point is essential to avoid damaging the tuberosity. Where the anterior approach is used, the direction of the initial entry hole is critical to the success of nail insertion. It must remain anterior, just behind the anterior cortical bone. If necessary, a curette should be used to scrape away any remaining cancellous bone in the anterior part of the first 10 cm of the entry canal. This will ensure that the direction of the nail is in the line of the bone, and not in a posterior direction, which would result in the nail perforating the distal posterior cortex. If there is any difficulty in inserting an unreamed nail by this approach, it should be removed. A guide wire with olive should be inserted, and the proximal metaphysis should be reamed to 10 or 11 mm, as described on the next pages. THIS PART OF THE OPERATION IS CRUCIAL, AND ADEQUATE TIME SHOULD BE TAKEN TO ENSURE CORRECT POSITIONING OF THE ENTRY PORTAL BEFORE PROCEEDING TO THE NEXT STAGE.

The entry portal is now ready for the insertion of an unreamed nail, or a guide wire prior to reaming. In the following figures describing the operation, the superior approach is shown.
REAMING PROCEDURE

If an unreamed nail is to be inserted, ignore the following section on reaming, and proceed to the section on Nail Insertion, on page 12.

Guide Wire Insertion

Throughout this procedure, care should be taken to retract the patellar tendon away from the operating field, to avoid damaging it, utilizing a self-retaining retractor, and to use the tissue protector to avoid bruising the articular surface of the patella, or the overlying skin. The guide wire with olive is now inserted through the hole and passed along and through the proximal fragment. Once the proximal end of the fracture line has been reached, the guide wire is manipulated in such a way that it reaches the distal fragment. A bend in the tip may be necessary to allow the surgeon to control the direction of insertion by turning the wire. In difficult cases, it is useful to clamp a T-handle on to the proximal end of the wire for additional control. Guide wire insertion must be carried out under image intensification in two planes. In mid-shaft fractures, the path of the guide wire is dictated by the contour of the medullary canal, and this may help to prevent valgus or varus displacement of the distal fragment. The guide wire is inserted until its tip sits 0.5-1 cm proximal to the ankle joint, care being taken to ensure that it is exactly in the midline.

It must be remembered that the reamer will follow the guide wire, and that the nail will follow the same track. If the tip of the wire is positioned too far medially, the end of the nail will in turn be medial, and a valgus deformity will result. Similarly, if the tip of the wire is too lateral, a varus deformity will result. These deformities are more likely to occur in fractures distal to the isthmus, where the nail is not automatically centered by the diaphyseal cortex. Another important reason for the central positioning of the guide wire is that an eccentric wire may result in asymmetrical reaming, with a disproportionate amount of cortex being removed on one side.
Reaming

The medullary canal is now reamed by passing the reamer over the guide wire, always starting with the 9 mm reamer. Reaming should then be continued in 0.5 mm increments, up to a width 1-2 mm greater than the nail diameter, 1 mm normally being sufficient. A soft tissue protector should be used proximally. Reaming past the isthmus is generally sufficient except in the case of a distal fracture, where reaming should be extended beyond the fracture line. Steady pressure should be exerted while reaming, and a check should be made that the reamer is advancing at all times. Excessive pressure, or a reamer that is not advancing, may indicate that the reaming head has become clogged with bone debris. It is very important in these cases to remove the reamer and clean the head. In young patients with hard bone this may be necessary more than once. If the reamer will not pass easily in spite of cleaning the head, it should be removed, and the previous size inserted, and passed slowly up and down the canal twice. A check should also be made to ensure that the reaming heads are being used in the correct order, in increments of only 0.5 mm. A reamer that is not advancing for any reason may cause significant thermal damage to bone and soft tissues. The reamer may jam if the power is turned off while it is in the canal, and this should be avoided.

The guide wire may slip back a little when the reamer is withdrawn, especially in distal fractures. This problem may be eliminated if the guide wire is lightly tapped prior to reaming, to embed it in the hard cancellous bone above the tibial plafond. It should also be kept in this position by gentle pressure at the proximal end during withdrawal of the reamer. Finally, when reaming is complete, the incision should be irrigated with normal saline to ensure the removal of all fragments of bone, to help prevent heterotopic ossification, which may be one of the causes of post-operative knee tenderness.
OPERATIVE TECHNIQUE

NAIL INSERTION

Reamed Nail

The Plastic Guide Wire Exchange Tube (17353) is inserted over the guide wire with olive, so that it is well across the fracture site. Holding the tube in place, the guide wire is now removed, and the 3 mm smooth guide wire, 480 mm long, (17469) is inserted. After confirming that the tip of the guide wire is in the correct position, the plastic tube is removed.

A nail of correct diameter and length is now selected. The Locking Rod (17430) is inserted into the back of the Handle (17410) and the chosen nail into the nail support.

The nail must be rotated until it seats into the correct position and the locking rod is then firmly tightened into the nail, completing this with the 5 mm Allen Wrench. Before the nail is inserted, it is important to check alignment of the distal and proximal holes in the nail and the guide bar. In order to do this, the guide bar is mounted on to the handle following the procedures described below under “Distal Locking” pages 14-18 and “Proximal Locking” pages 21-22.

The nail is now manually inserted over the guide wire as far as possible, under image intensification. The guide wire should be removed when its exit point from the nail is at the level of the entry portal. The nail is advanced into the distal fragment until the step on the nail support is flush with the surface of the bone. This indicates that the nail has been inserted to the correct depth. Ideally, the nail should be inserted by hand, but gentle tapping may be necessary.
The Sliding Hammer (17392) or the Strike Plate (17477) may be attached to the end of the nail locking rod, and either one must be tightened fully to avoid damage to the thread. The nail can then be inserted into the correct position by gentle hammering. Ideally, the proximal end of the nail is recessed in the bone by 10-15 mm. If the nail will not advance, it should be removed, after replacing the guide wire, and the bone reamed an additional 0.5 mm. If this is unacceptable, a smaller diameter nail should be inserted.

Note: After the Sliding Hammer or the Strike Plate have been removed, a check should be made to ensure that the locking rod is tightened firmly.

Unreamed Nail

The internal diameter of the isthmus of the tibia should be checked using the 8 and 9 mm Tibial Sounds (17475 and 17476). It is always preferable to use a 9 mm nail if possible. The 8 mm or 9 mm nail is locked firmly to the nail support handle with the locking rod as for the reamed nail. It is then inserted through the entry portal into the medullary canal, and advanced manually as far as possible, using X-ray control. It will normally be necessary to attach the sliding hammer or strike plate, as described above, to complete the insertion, hammering as gently as possible. Care should be taken to ensure that the nail remains parallel to the tibial diaphysis, to avoid perforation of the cortex.

If the nail will not pass in spite of hammering, the situation should be carefully reviewed with the Image Intensifier. The tip of the nail may be striking the posterior cortex. In this case the nail should be removed by reverse hammering, and the direction of the entry portal adjusted. If the nail will not pass, but the direction seems to be correct, it should again be removed, and consideration given to using a smaller nail, or to reaming. At the end of insertion, the fracture site should be checked by X-ray to see whether nail insertion has caused any distraction of the fragments. Distraction at the fracture site for any length of time may be associated with compartment syndrome, and must be avoided. If at all possible, any distraction should be corrected now by compression between heel and knee. If full correction is not achieved at this time, it can be effected following distal locking, which in this case must be done first. It is also important at this stage to check for axial reduction in the sagittal and coronal (frontal) planes.

Note: Both reamed and unreamed nails can be advanced by gentle rotational movements until the bend in the nail reaches the surface of the bone. After this the nail must be advanced without rotation by pushing or hammering.
It is generally recommended that distal locking is performed first, because it is potentially more difficult. In very proximal or unstable fractures, however, it may be preferable to carry out proximal locking first.

The guide bar is introduced into the handle, moved downwards until the number corresponding to the nail length is at the level of the front of the handle, and locked firmly into place. Note that there is a depression for the tip of the bar locking screw corresponding to each nail length. The distal locking screws are inserted in the frontal plane, normally from the medial side. On rare occasions, because of skin damage medially, or because of the configuration of a distal fracture, the surgeon may wish to insert the screws from the lateral side. In this case the distal outrigger is placed on the lateral side, and the nail is rotated so that the locking screws will pass anterior to the fibula. The procedure for distal locking is then identical to that for the more usual medial approach.

The distal outrigger is mounted on the guide bar so that it lies on the correct side of the tibia, and the Screw Guides (17360) are inserted into the outrigger, but no incision is made as yet. The system is first stabilized in exact alignment, utilizing the T-Handled Stabilizing Rod (17481).

A Drill Guide (17365) is inserted into one of the two holes in the guide bar proximal to the distal outrigger. An incision is made in the skin directly beneath it, and the anterior tibial cortex exposed by blunt dissection, taking care to deflect the tendon of Tibialis Anterior laterally to avoid damage to it or to the neurovascular bundle. The drill guide is advanced until its teeth are engaged in the tibia, and stabilized on the center of the tibial crest. The drill guide may be lightly tapped to engage the teeth in the bone, and a 4 mm drill bit is now used to drill the anterior cortex only. The drill bit is removed.
The square ended 4 mm T-handled Reamer (17426) is passed down the drill guide, and used to complete the hole down to the nail, and to remove intervening debris. It should be possible to feel and hear the tip of the reamer touching the nail. The T-handled reamer and drill guide are now removed, and replaced by the T-handled Stabilizing Rod (17481), which is inserted through the anterior cortex down to the nail, again gently tapping it on to the nail to confirm that there is no intervening debris.

The T-handled stabilizing rod must now be fixed in an exact position according to the diameter of the nail, and this is achieved by clipping the appropriate U-Shaped Stabilizing Spacer (17482-4) on to the guide bar, so that its forks engage the two recesses in the stabilizing rod. The three spacers are each calibrated for two nail diameters, with a figure from 8 to 13 engraved on each side. A spacer should be positioned so that the correct nail diameter is visible on the upper surface, facing towards the surgeon.
The assistant now exerts gentle pressure on the T-handle of the stabilizing rod, so that its tip is pressed against the nail. This ensures that the distance between nail and guide bar is constant, allows for any deformation of the nail in the sagittal plane, and maintains the alignment for the distal targeting. It also stabilizes the guide bar and outrigger, so that the surgeon has a secure platform for drilling the distal holes. It is possible, if the assistant presses too hard, for the tip of the stabilizing rod to be pushed past the nail. Normally, gentle pressure only is required, and the assistant should be able to feel the contact between the tip of the stabilizing rod and the nail at all times. On occasion, a gentle UPWARD or DOWNWARD pressure may be necessary to ensure that the tip of the stabilizing rod remains in contact with the anterior portion of the nail.

There is a circular groove one millimeter from the tip of the stabilizing rod. This groove can be used in conjunction with a lateral X-ray to confirm that the tip of the stabilizing rod is just touching the nail.

An incision is now made beneath each screw guide, and the cortex exposed in each incision by blunt dissection, taking care to avoid entrapment of, or damage to, the neurovascular structures. Similarly, if the approach is from the lateral side, the surgeon must ensure that the tendons and vessels are not damaged during the locking procedure, by careful soft tissue dissection down to the bone. The screw guides are then advanced until they are in contact with the cortex, and the clamp locking nut on the outrigger tightened to hold them firmly in place.

As with all distal locking procedures, the surgeon’s drilling technique is vital to the success of the procedure. It is important that the drill is held securely in line with the drill guide, avoiding any bending of the drill bit. Excessive force should be avoided, so that the surgeon can “feel” the drill passing through the bone and the nail. If the drill has a pistol grip, it is very important that the force applied during drilling is axial to the drill bit, and directly in line with it. Pressing on the handle of this type of drill causes a bending force to be transmitted to the drill bit, and this may be sufficient for it to miss the holes in the nail.

The assistant maintains constant contact between the tip of the stabilizing rod and the nail throughout this procedure, if necessary, by applying gentle pressure. The 4 mm drill guide is inserted into one of the screw guides, and gently tapped to engage the teeth in the cortex. The surgeon continues to hold the handle of the drill guide with one hand until the first cortex has been drilled.
The drill stop is locked to the drill bit at the proximal end. The drill bit is introduced into the drill guide, down to the bone, before the drill is started, and gently pressed to engage the tip in the cortex.

The surgeon now drills steadily through the near cortex, and stops when the second cortex is reached. The drill stop is moved down until it is 7-10 mm above the top of the drill guide, and locked into place. This represents the thickness of the second cortex. Drilling now continues through the second cortex. The drill stop prevents damage to the tissues beyond the bone, and also provides a method of estimating the correct length of the locking screw.

The drill bit is removed with the drill guide. The graduated angled trocar is now inserted into the screw guide, so that it passes through the nail, and engages the far cortex. This trocar should now have stabilized the position of the guide bar and outrigger in relation to the nail, and its position can be confirmed by manipulation or with the Image Intensifier. Now that screw guide alignment is maintained by this trocar, the assistant may release the T-handle of the stabilizing rod.

The appropriate locking screw length, from the base of the screw head to its tip, is determined by measuring the amount of drill bit protruding from the drill guide, and a scale is provided for this on the locking screw extractor. The tapered tip of the drill bit should be ignored in this measurement. A screw of the correct length is reserved. An alternative method of screw measurement using the Depth Gauge is described on page 19.
The drill stop is now replaced at the proximal end of the drill bit. The second locking hole is now drilled, using exactly the same technique. The length of the second locking screw is determined.

A locking screw of correct length is now inserted into the second screw guide, and pushed through the bone with the Screw T-wrench (17350), until its thread engages the cortex. Note that there is a circular mark on the T-wrench. This mark will be 7-12 mm above the top of the screw guide when the locking screw has been pushed in sufficiently, depending on the length of the thread on the screw. There is no point in turning the T-wrench until this position is reached, because there will be no thread in contact with the bone. The T-wrench is now turned steadily clockwise, exerting gentle pressure, until the mark on the shaft of the T-wrench reaches the top of the screw guide. One more complete turn should then be made to tighten the screw fully. It is important not to continue turning after this position is reached, because the thread in the bone may be stripped, necessitating the use of a revision locking screw (see page 20).

The assistant again holds the T-handled stabilizing rod, and the graduated angled trocar is removed from the first screw guide. The same technique is followed for insertion of the second distal locking screw, after which both screw guides are removed by loosening the clamp locking nut. A check should now be carried out with the Image Intensifier or radiograph to confirm that both locking screws have passed through the nail and to confirm that the reduction has been maintained. The distal outrigger and the T-handled stabilizing rod are now removed.
If there is any doubt about the correct locking screw length, either in respect of the measurement obtained after drilling, or because the surgeon omitted this step, the Locking Screw Depth Gauge (17351) may be used as follows: the surgeon should first check that the screw guide is positioned so that it is touching the bone. The depth gauge cover is then unscrewed and removed.

The hooked end is inserted down the screw guide and through the bone. It is then drawn back so that the hook engages the outer surface of the far cortex. The correct length of screw can now be read at the top of the screw guide. This depth gauge is only suitable for use with Orthofix Tibial and Femoral Nails, since its accuracy depends on a fixed length of screw guide.
LOCKING SCREW REPLACEMENT

If a locking screw should need replacing for any reason during the course of the operation, the T-Handled Locking Screw Extractor (17652) should be used, as described in the section on Nail Removal at the end of this manual.

REVISION LOCKING SCREWS

These have a thread diameter of 8.0 mm, and should be inserted through screw guides in the normal way. They should be used in situations where the thread of a standard screw does not have sufficient purchase for any reason, e.g. in osteoporotic bone.
CHECK FOR FRACTURE DISTRACTION

Before proximal locking is carried out, the fracture should be screened to check for any distraction. If this is present, the sliding hammer can be reattached to the locking rod as described previously. The fracture gap can then be closed by gentle reverse hammering, after which the hammer is removed. It is very important to avoid completing the locking of the nail with the fracture distracted. There is an association between fracture distraction, and delayed union or compartment syndrome.

PROXIMAL LOCKING

The guide bar locking screw is loosened, and the bar moved until the P mark is level with the front surface of the handle, where it is locked into position.

The proximal outrigger is mounted on the bar, and two screw guides inserted into the guide seats to locate the sites for the incisions. Before making the incisions, the surgeon should carry out a final check for reduction of the fracture, remembering the possibility of distraction. An incision is made beneath each screw guide, and the tibial cortex exposed in each case by blunt dissection. The screw guides are advanced down to the cortex and locked in position with the clamp locking nuts. The medial hole is drilled first.
A drill guide is inserted into the medial screw guide, and tapped gently to engage its teeth in the cortex. The drill bit is introduced down to the bone, and pressed against the cortex to fix the tip before drilling begins. The graduated angled trocar is inserted after this hole is drilled, and final alignment confirmed. The lateral hole is now drilled, the screw length determined, and the screw inserted. The graduated trocar is then removed, and the medial screw inserted.

**Final Check**

A final check is now made to confirm that fracture reduction is satisfactory, and that all four locking screws are correctly inserted through the nail, the screw heads flush with the bone, and the distal ends just protruding beyond the second cortex.

**REMOVAL OF THE JIG ASSEMBLY AND CLOSURE**

The proximal outrigger is removed, the guide bar locking screw loosened, and the guide bar removed.

At this stage, the handle is removed after loosening the locking rod a few turns with the 5 mm Allen wrench.

Once the locking rod and the handle have been removed, a Nail End Cap (74401) is placed over the end of the nail. The nail end cap is cannulated, and in difficult cases a 2 mm Kirschner wire, 150 mm long (11146) may be threaded into the lumen in the proximal end of the nail, and used as a guide to locate the correct position for the cap. The nail end cap is screwed tight with the T-wrench.

Closed suction drainage is advised for the insertion wound. All incisions should be sutured in layers in the usual way. Firm dressings should be applied to prevent hematoma formation. The drainage is removed after 24-48 hours.
WEIGHTBEARING

The patient is mobilized on crutches immediately, but the knee is rested in an immobilizer for 1-2 days. Dressings are changed daily, and, after the drain has been removed, the knee may be mobilized freely. With a stable fracture, a patient may weightbear as able, increasing to full weightbearing by 4 weeks. If the fracture is unstable, toe touch weightbearing is permitted immediately, with gradually increasing partial weightbearing over the next 6 weeks. Full weightbearing is only advised once there is some continuity of callus across the fracture site. Fractures with severe comminution, of Winquist-Hansen types IV and V, should be supported before weightbearing with an external brace, if an 8 mm or 9 mm nail has been used, until the fracture is healed.

DYNAMIZATION

Dynamization, by removal of one pair of locking screws, is not recommended as part of the standard technique. However, should there be no callus formation at 12 weeks, removal of the pair of screws furthest from the fracture site is advised, provided that the fracture is stable. If the fracture is unstable, exchange nailing with a larger reamed nail should be considered. The surgeon should try to avoid continued fixation with an 8 or 9 mm nail if delayed union is present. In this situation, exchange nailing with a larger diameter cannulated nail is preferable. If the fracture site looks atrophic, further local measures to encourage union may be needed.

RESUMPTION OF NORMAL ACTIVITY

Patients employed in light work or in an office may resume their job as soon as they are fully comfortable, assuming that the state of the soft tissues is satisfactory. Patients in work that is heavy or involves potentially dangerous situations should not be allowed back before the bone is radiologically united, and this is rarely less than six months after the injury.
NAIL REMOVAL

Nail removal may normally be carried out after 18-24 months provided that there is radiological evidence of union. Union may be expected to occur after 6 months with nailing procedures in the tibia. The situation may be different in open fractures, non-unions or corrective osteotomies. In such cases the nail should be left in situ for a minimum of 24 months.

The proximal end of the nail is exposed through a small incision. It may be necessary to clear some new bone from the end of the nail. The nail end cap is removed with the T-wrench, and the Screw Adapter (17491) is screwed on to the nail, and tightened firmly. This should be accomplished prior to the removal of the proximal locking screws to prevent the nail from deflecting posteriorly.

The locking screws are now all removed. When locking screws require to be removed for any reason, (e.g. nail dynamization or extraction, or in the occasional case where the length of the chosen locking screw is incorrect), this may be accomplished using the T-Handled Locking Screw Extractor (17652) as follows: the extractor is inserted down to the head of the screw, and is turned counterclockwise. The thread on the outside of the locking screw head is a reverse thread, so it is necessary to turn the extractor counterclockwise throughout this procedure. The first turns lock the extractor to the screw head, and further turns will release the screw thread from the bone. Once the thread has been disengaged from the cortex, the screw should be pulled out directly. Further turns at this point will achieve nothing, as no thread remains in the bone.

Note that the locking screw is then disengaged from the extractor by turning the latter clockwise, which is the opposite direction to normal. It may be necessary to grip the smooth shaft of the screw with forceps during this procedure.
The nail is then removed, either by manual traction on the screw adapter, or by reverse hammering, after screwing the Sliding Hammer (17392) on to the proximal end of the adapter.
EXTERNAL FIXATION

PM 010 ORTHOFIX EXTERNAL FIXATION: BASIC CONSIDERATIONS

PM 020 GROWTH PLATE DISTRACTION
   – Chondrodiatasis
   – Hemichondrodiatasis

PM 030 LIMB LENGTHENING AND CORRECTION OF DEFORMITIES BY CALLUS DISTRACTION
   – Callotasis
   – Hemicallotasis
   – Tibial lengthening and angular correction with the OF-Garches limb lengthener

PM 040 ARTHRODIATASIS (Articulated Joint Distraction)
   – Hip
   – Ankle

PM 050 ARTHRODESIS (Joint Fusion)
   – Shoulder
   – Hip
   – Knee
   – Ankle

PM 060 DIAPHYSEAL FRACTURES
   – Humerus
   – Forearm
   – Femur
   – Tibia

PM 070 DISTAL TIBIAL AND PILON FRACTURES

PM 080 PELVIC APPLICATIONS

PM 090 TREATMENT OF FRACTURES AND DEFORMITIES IN SMALL BONES

PM 100 THE PENNIG DYNAMIC WRIST FIXATOR

PM 110 THE LIMB RECONSTRUCTION SYSTEM
   – Part A: General Principles
   – Part B: Correction of Deformities

PM 120 THE RING FIXATION SYSTEM
   – Part A: The Hybrid Fixator
   – Part B: The Sheffield Ring Fixator - Standard Trauma Applications
   – Part C: The Sheffield Ring Fixator - Limb Reconstruction and Complex Trauma

INTERNAL FIXATION

PM IKD Intramedullary Skeletal Kinetic Distractor:
   Tibial Surgical Technique

PM IMT The Orthofix Tibial Nailing System

PM IMF The Orthofix Femoral Nailing System

PM AAN The Ankle Arthrodesis Nail

PM RFN The Retrograde Femoral Nailing System

PM PRD PORD™ DEVICE
   Posterior Reduction Device for Hip and Femoral Fractures

PM PCP THE GOTFRIED PC.C.P
   for Percutaneous Compression Plating of Pertrochanteric Hip Fractures
Orthofix wishes to thank

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