



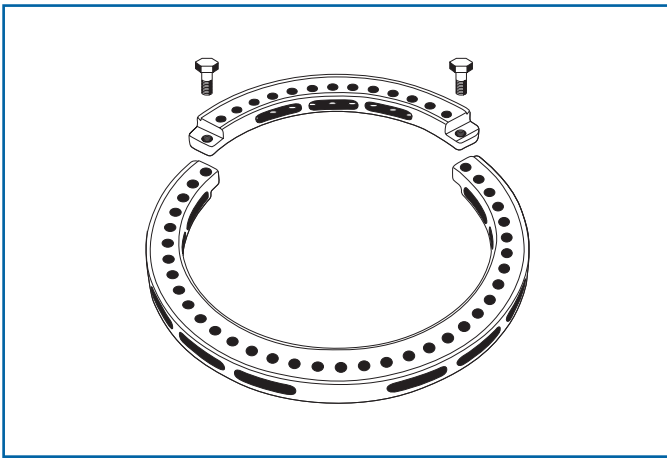
The Ring Fixation System

Part A: The Hybrid Fixator

By Prof. M. Saleh

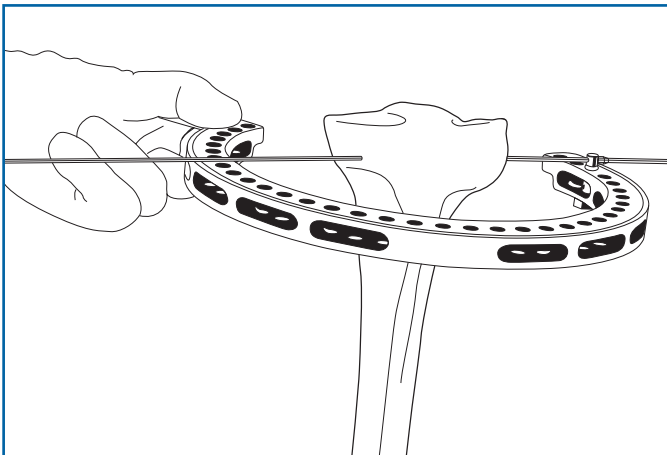


	Page N°
QUICK REFERENCE GUIDE	I
INTRODUCTION	I
Indications for Use.....	I
EQUIPMENT REQUIRED	2
Instruments.....	6
CLEANING AND STERILIZATION	9
PRE-OPERATIVE PLANNING: STERILIZATION	10
Selection of Ring Size.....	10
Selection of Ring Size/Wire Combination.....	10
PROXIMAL TIBIAL METAPHYSIS	11
Operative Technique.....	12
DISTAL TIBIAL METAPHYSIS	19
Operative Technique.....	20
DISTAL FEMORAL METAPHYSIS	21
POST-OPERATIVE CARE AND PROBLEM SOLVING	22
Pin Site/Wire Site Care.....	22
Weightbearing and Physiotherapy.....	22
Dynamization.....	22
Frame Removal.....	22
REFERENCES	23



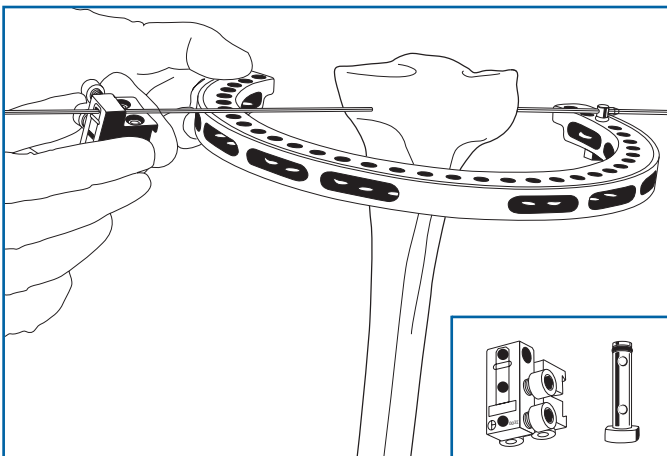
Kirschner Wire Insertion

Choose appropriate ring.
 Full circumference rings may be made by joining 1/3 and 2/3 rings together with locking screws.



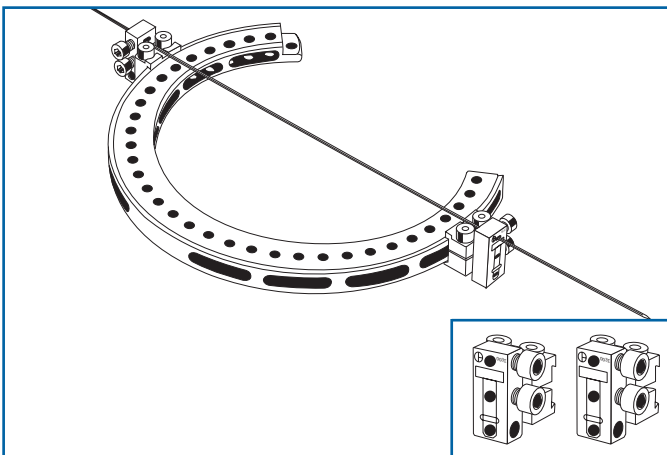
Reference anatomically safe corridors on cross-section of limb. Insert wire closest to the joint first. Insert a two-hole securing pin into appropriate hole in ring. Introduce tip of K-wire with lateral olive through the two-hole securing pin. Push wire through soft tissues and drill through bone, while assistant maintains ring at 90 degrees to bone axis with limb centered within it. Avoid joint capsule. When wire has exited far cortex, stop drilling and ensure wire is parallel to ring and joint line. Continue to advance wire by tapping it with mallet, until lateral olive is against securing pin.

NB: Wire may be drilled above, below or through the ring, for best position relative to fracture and joint capsule.

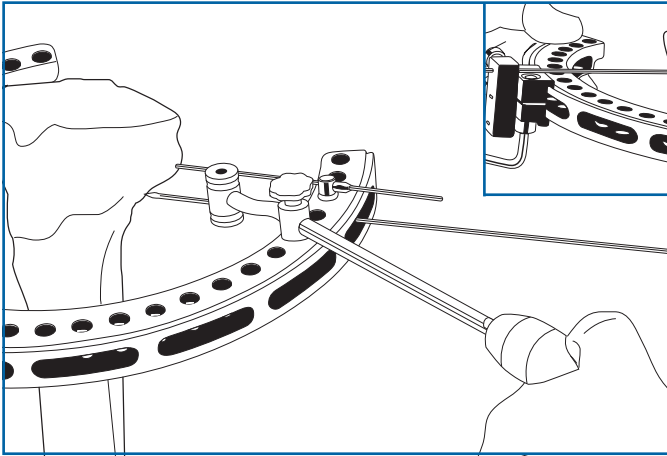


Loosen all screws of three-hole wire clamp slider unit. Orient clamp in same direction as securing pin. Introduce wire into appropriate hole in slider unit.

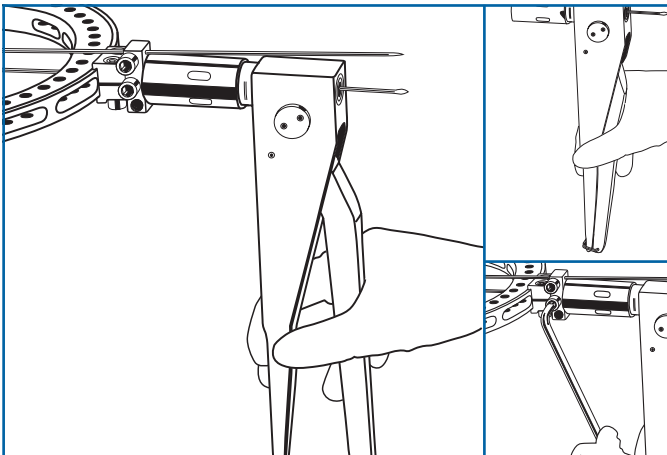
NB: First wire may be inserted free-hand. Use a K-wire without olive and attach it to ring using a three-hole wire clamp slider unit at each end.



Tighten both slider units to ring, then tighten wire clamp screw on one end of wire.

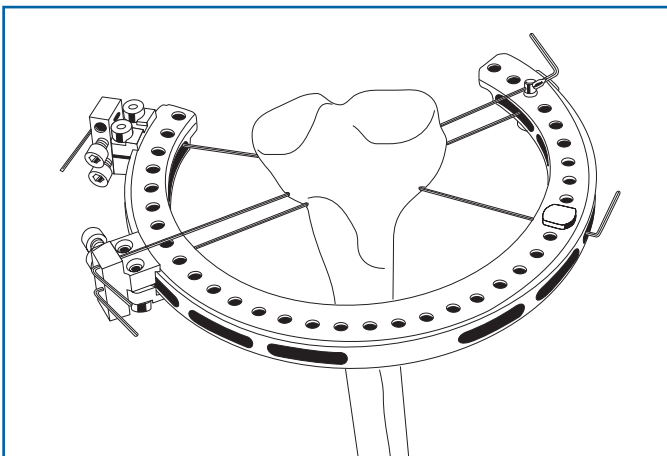


Insert parallel wire next through second hole in securing pin, using wire guide.
 Disconnect the slider unit temporarily from the ring and then insert it over both wires.
 Tighten slider unit on to ring fully, using 3 mm Allen wrench.
 Position limb in center of ring.



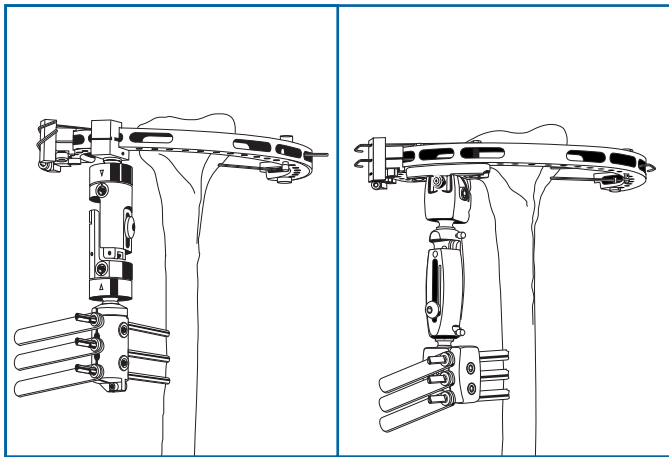
To tension wires, open handle of wire tensioning device to fullest extent. Fully insert wire through the device sliding it up against face of slider unit. Tension wire to minimum of 1200 N, in two stages if necessary.
 Tighten wire clamp screws with 5 mm Allen wrench.
 Cut and/or bend wire and apply wire cover.

NB: Where K-wires without olive have been used in conjunction with three-hole wire clamp slider units at each end, apply tensioning device to end of wire which has not yet been tightened in its slider unit and tension as above.



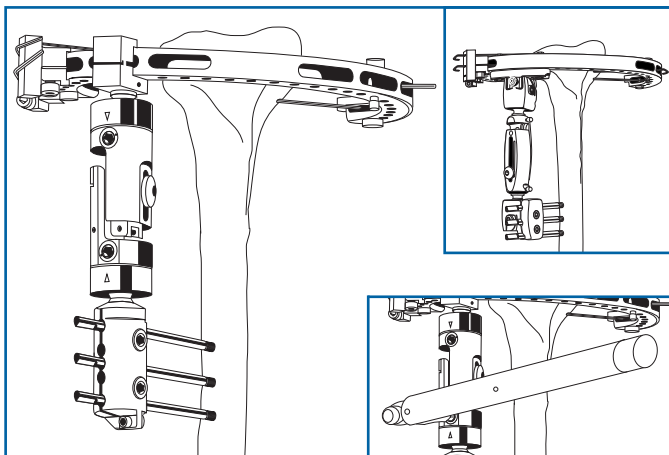
Insert crossing wires at widest angle neurovascular structures will permit (usually between 50°-70°).
 For optimal ring stability wires should cross in the center of the tibia.
 Insert the securing pin into the ring, upside-down relative to the first securing pin to prevent wires from intersecting in bone.

Diaphyseal Screw Insertion



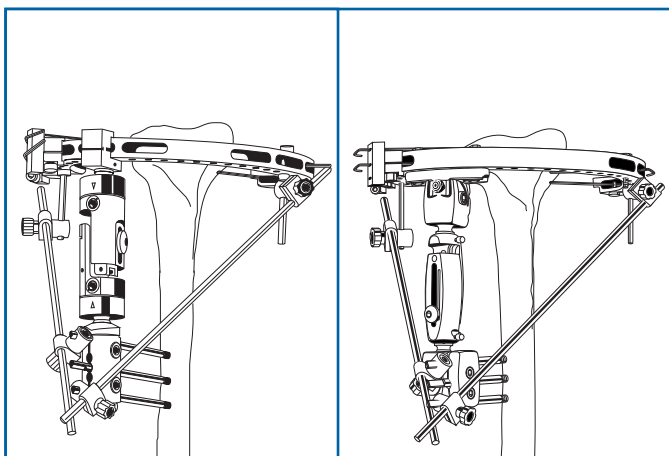
Reduce fracture further by manipulation of ring and limb. Attach fixator to ring, using the coupling with ball-joint if the ProCallus Fixator is used, and lock with 3 mm Allen wrench. Position fixator parallel to long axis of bone with cams and all locking nuts accessible for tightening. Make sure fixator body is neither fully closed nor fully open.

Clamp acts as its own template for screw insertion. Insert bone screws in standard manner (See Manual 1, "Orthofix External Fixation: Basic Considerations"). Where two screws are inserted, use clamp seats 1 and 5; where three are inserted, use seats 1, 3 and 5.



Confirm fracture reduction.

Lock micromovement locking nut, central body locking nut and ball-joints of the fixator with the 6 mm Allen wrench. Use torque wrench for final locking of ProCallus ball-joints only.



Reinforcement bars may be added to increase stability.

Insert post through ring and attach bar using a supplementary screw holder clamp.

Attach opposite end of bar to bone screw using another supplementary screw holder clamp.

As healing progresses, remove reinforcement bars to increase load sharing at the fracture site.

The Orthofix XCaliber Meta-Diaphyseal Fixator or the ProCallus Fixator with a T-Clamp or a Metaphyseal Clamp may be used to stabilize metaphyseal and articular fractures. Severe comminution or poor bone stock, however, may lead to early screw loosening in the metaphysis because of repetitive loading under cantilever conditions.

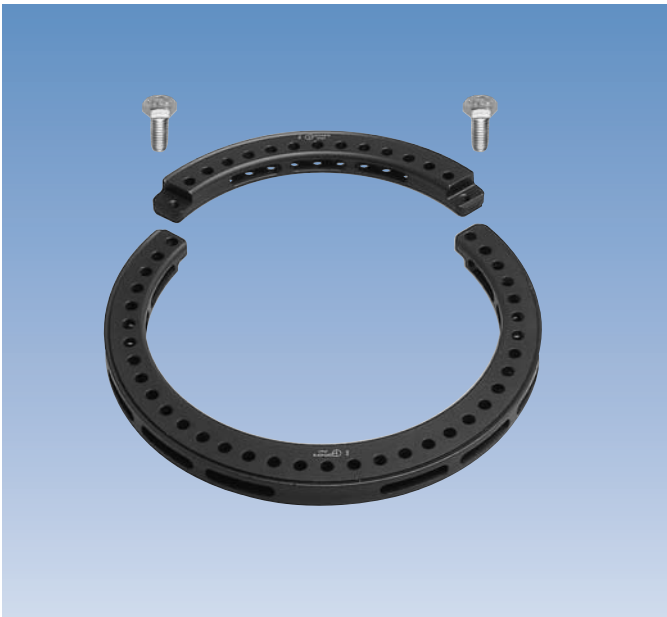
Tensioned wires are easy to apply in the metaphysis, with broad, safe corridors to maximize wire crossing angles, and provide good long term fixation in metaphyseal bone.

In the diaphysis, however, the use of tapered 6-5 mm monolateral cortical screws is known to give excellent long term fixation.

A Hybrid Fixator, therefore, provides optimal bone purchase by combining tensioned wire fixation in the metaphysis with cortical screw fixation in the diaphysis¹.

INDICATIONS FOR USE

Metaphyseal and articular fractures in the proximal and distal tibia and the distal femur.

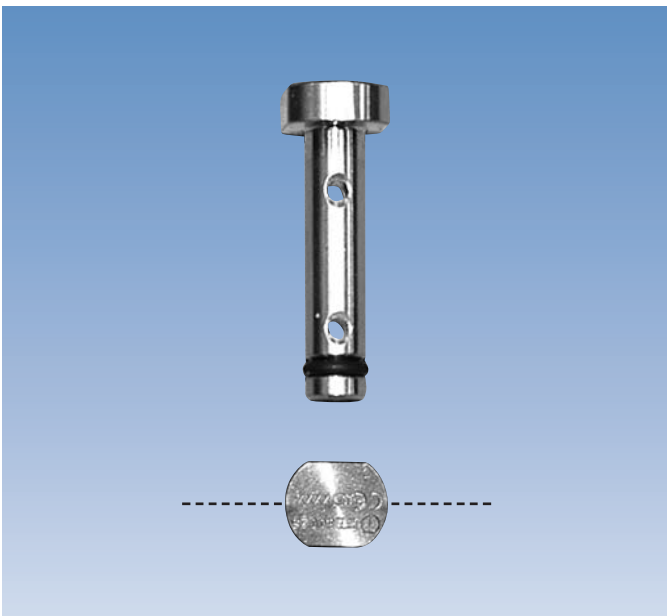


2/3 - 1/3 Rings

The rings are available in 2/3 and 1/3 configurations, and can be assembled together to create a full ring. 2/3 rings are commonly used near the joints to allow joint flexion through the opening in the ring. The rings are available in the following sizes:

Ring Size: Inner Diameter	2/3 Ring	2/3 Radio Lucent Ring	1/3 Ring	1/3 Radio Lucent Ring
125 mm	81050A	81125	81051	81125P
150 mm	81000A	81150	81001	81150P
175 mm	81002A	81175	81003	81175P
190 mm	81004A	81190	81005	81190P
220 mm	81006A	81220	81007	81220P

The rings are assembled with two:
81008 Ring Locking Screw (length 16 mm)



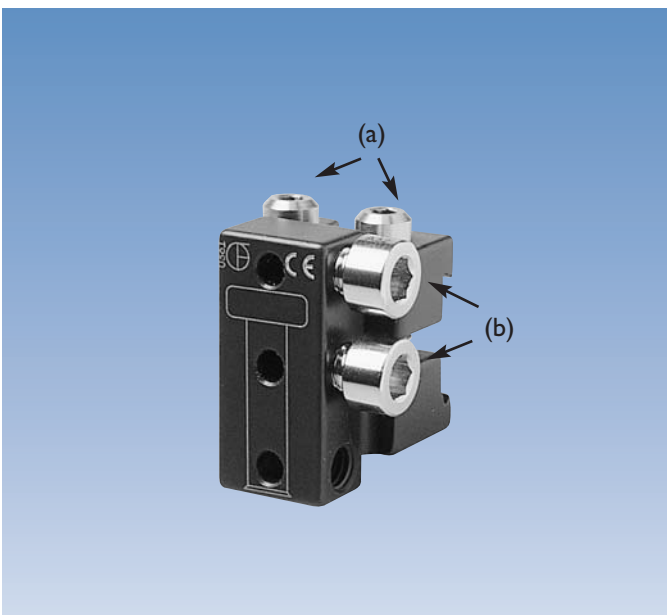
Wire-Ring Securing System

80025 Two-Hole Kirschner Wire Securing Pin

A 6 mm rod with two 2 mm diameter holes for the Kirschner wires. The hole in the securing pin closer to its head is offset from the center of the ring slot. This avoids contact between the crossing wires at the bone interface.

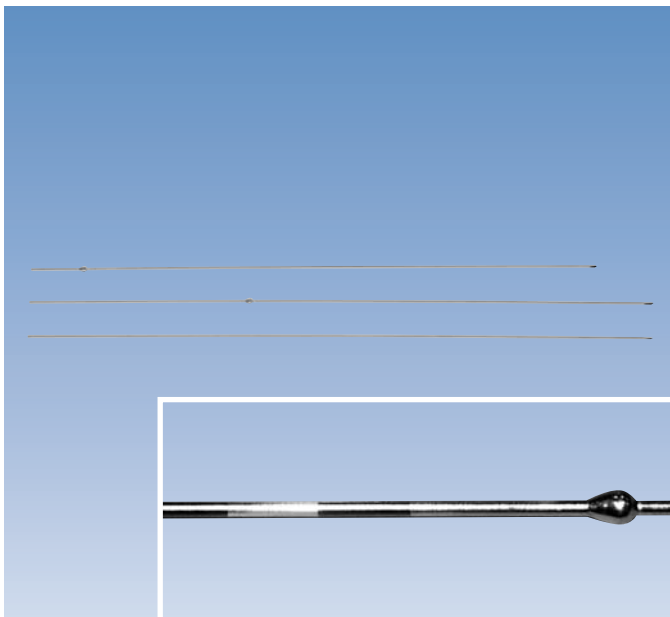
It may only be used with Kirschner wires with lateral olives. Wires without olive may be used, but require a wire clamp slider unit at each end to secure the wire to the ring.

Note: the squared edges on the head of the pin line up with the holes for the wires, making it easier to insert the first wire.



80031 Three-Hole Wire Clamp Slider Unit

This component is used to secure wires to a ring. It has four screws: two (a) attach the slider unit to the ring, while the remaining two (b) grip the Kirschner wires in the slider unit, in any two of the three holes. The central wire hole is offset to avoid contact between the crossing wires in the bone. It may be used with all types of wire, allowing them to be placed above, below or through the ring. **Three-hole wire clamp slider units should be used with 1 or 2 wires only.**



Kirschner Wires

Kirschner Wire (2 mm diameter) with Lateral Olive

- 80112 Length 400 mm
- 80111 Length 350 mm
- 80101 Length 310 mm

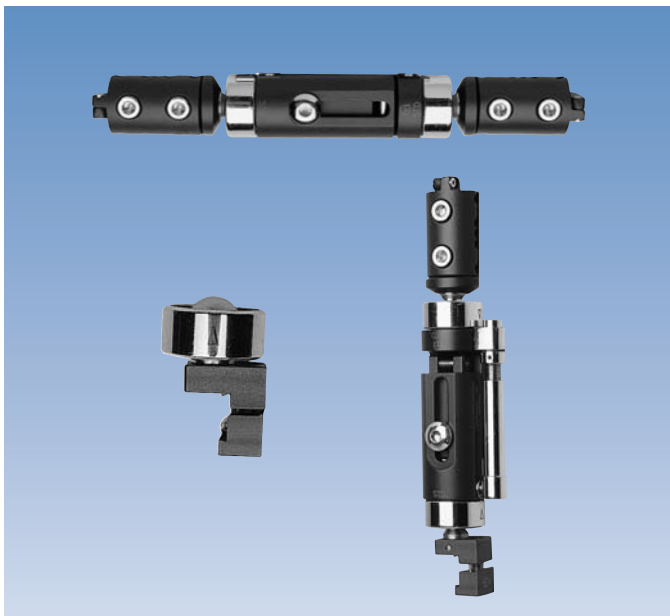
Kirschner Wire (2 mm diameter) with Central Olive

- 80123 Length 450 mm
- 80121 Length 400 mm

Kirschner Wire (2 mm diameter) without Olive

- 80124 Length 450 mm
- 80122 Length 400 mm

Note: all of the wires have markings at the end away from the tip. For the olive wires, this means that the markings are always on the same side of the bone as the olive. For removal, the central olive wires should always be pulled out by grasping the end with the markings.



ProCallus Fixator and Hybrid Coupling with Ball-Joint

- 90000 Standard Model
- 90028 Short Model
- 80050 Coupling with Ball-Joint for the fixator

This coupling is also available preassembled with either the standard or short ProCallus fixator bodies.

- 80051 Hybrid Fixator Assembly Kit Standard
- 80052 Hybrid Fixator Assembly Kit Short

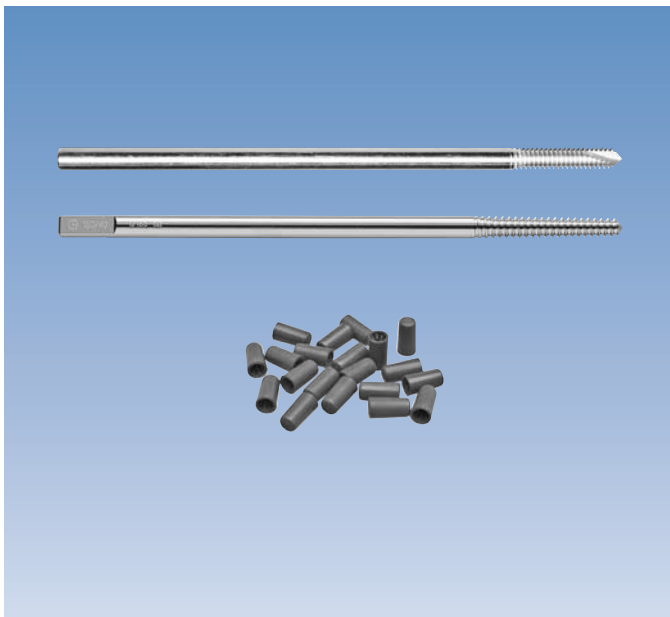


XCaliber Hybrid Fixator

- 99-91080 XCaliber Hybrid Kit, sterile

The XCaliber Hybrid Kit is packaged sterile, ready to use. The fixator is radiolucent and strictly single patient use.

EQUIPMENT REQUIRED



Screws

Either standard tapered cortical screws or XCaliber screws are used, but they should not be mixed. Suggested sizes:

Tibia:

10110 Standard Cortical Screw 110/30 mm or
911530 XCaliber screw 150/30 mm

10114 Standard Cortical Screw 130/40 mm or
911540 XCaliber screw 150/40 mm

Femur:

10165 Standard Cortical Screw 150/40 mm or
911540 XCaliber screw 150/40 mm

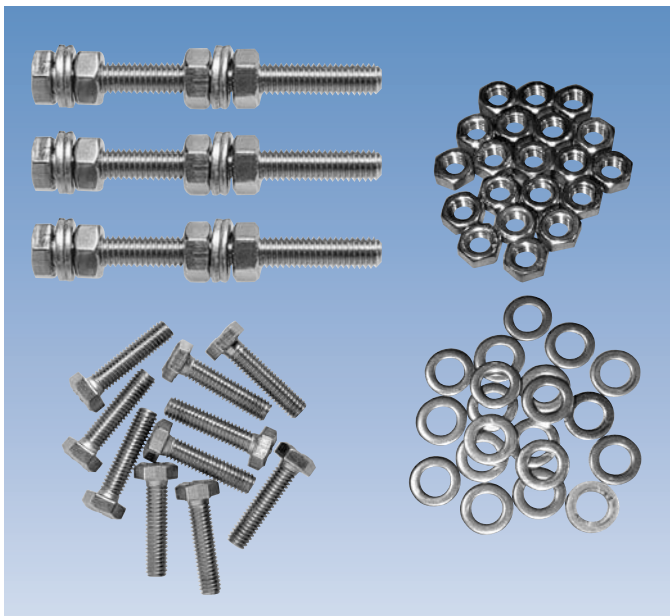
10103 Standard Cortical Screw 180/50 mm or
911550 XCaliber screw 150/50 mm

912640 XCaliber screw 260/40 mm

912650 XCaliber screw 260/50 mm

XCaliber screws are designed to be cut to length after insertion and fixator application.

10200 Sterilizable Screw Covers (set of 20)



Bolts with Nuts and Washers (set of 3)

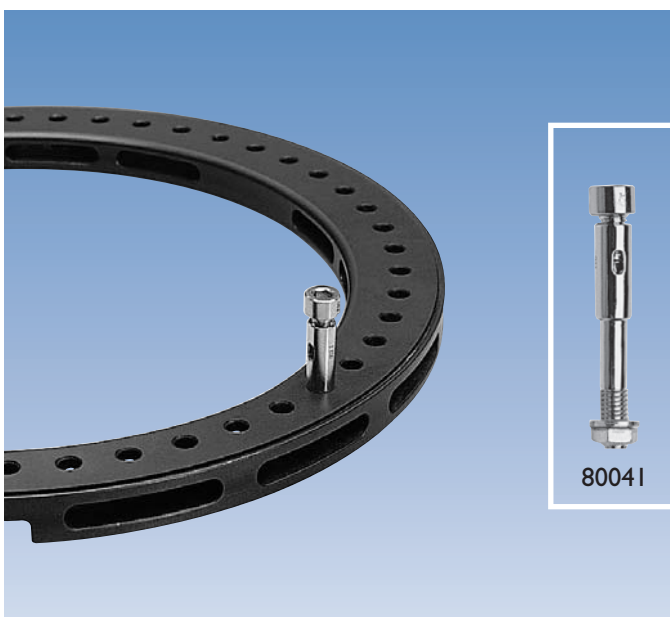
80034 Length 60 mm

Bolts without Nuts and Washers (pack of 10)

81024 Length 25 mm

81021 Length 35 mm

81022 Nuts and Washers (pack of 20 of each)



80041 Independent Wire Clamp

Used with a 2 mm Kirschner wire with central olive, to secure an unstable fragment. A Washer (W2200, set of 4) may be used over the wire to reinforce cortical contact.

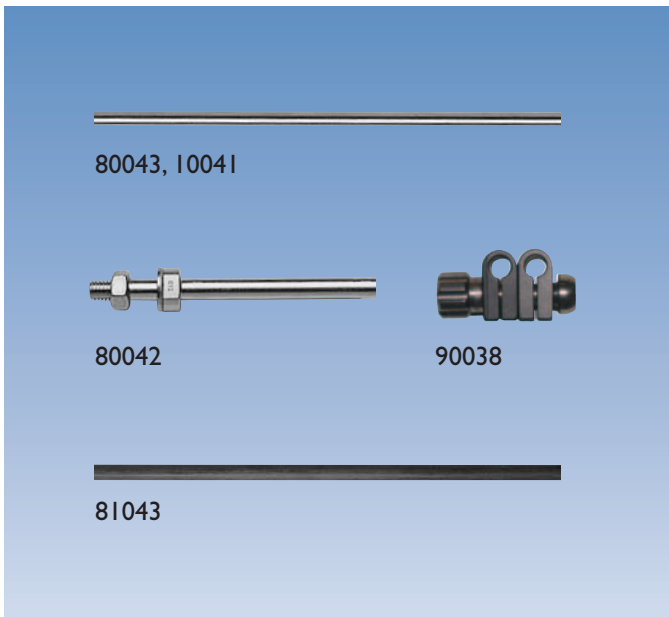
The Independent Wire Clamp is applied directly to the ring.

Reinforcement Bars

- 80043 Length 300 mm
- 10041 Length 400 mm

Two reinforcement bars are used in association with four Supplementary Screw Holder Clamps (90038) and two posts 50 mm long (80042) to increase the stability of the system (see page 18).

Reinforcement Bars, 300 mm long are also available radiolucent (81043).

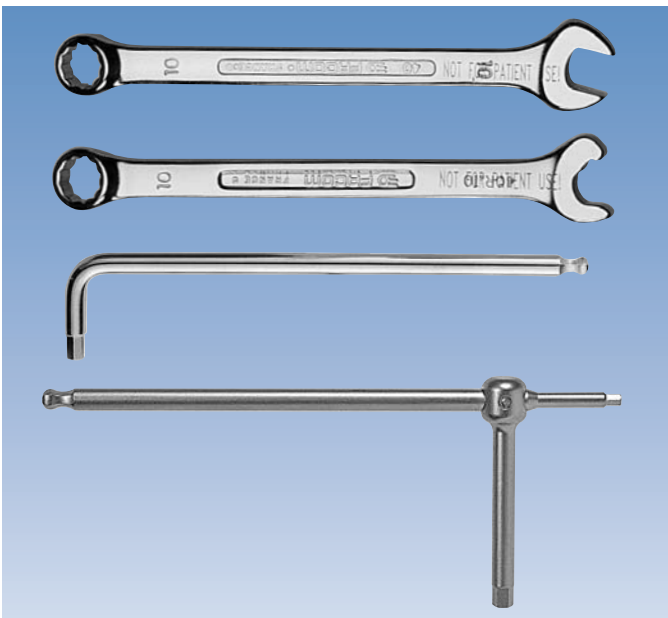




INSTRUMENTS

18001 Wire Tensioner

Calibrated from 600-1400N.

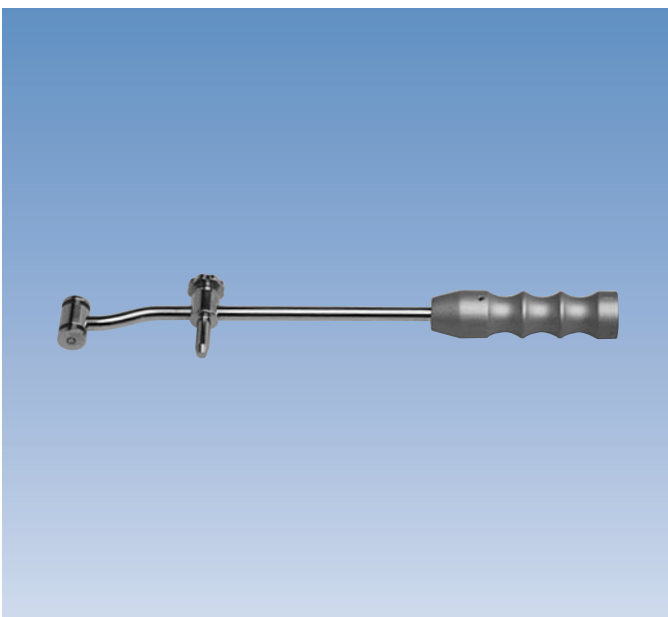


81031 Open End Wrench

81030 Speed Wrench

10017 Allen Wrench 6 mm

91017 Universal Allen Wrench 3 mm/5 mm and Wire Bender



18002 Wire Guide

Used as an aid to accurate placement of a second wire when parallel wires are used.

EQUIPMENT REQUIRED



W1003 Wire Cutter

80200 Kirschner Wire Covers (pack of 20)



Screw Guides

11102 Length 60 mm

11137 Length 80 mm

11103 Length 100 mm

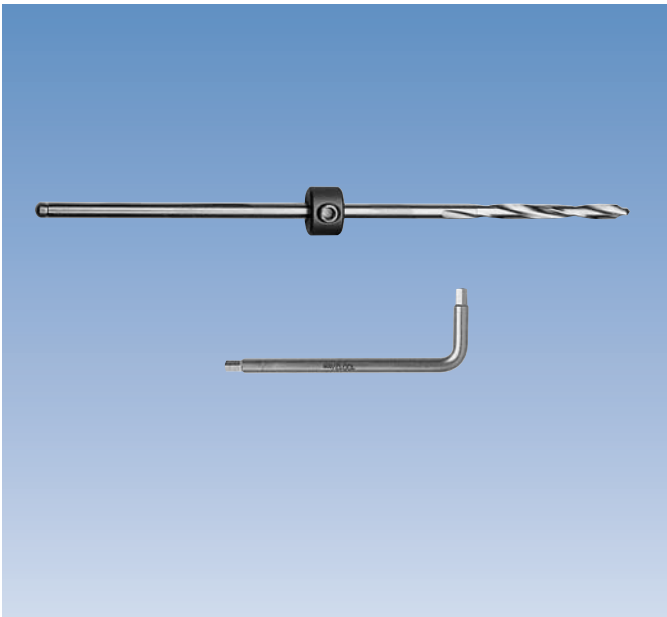


Drill Guides

11138 Length 60 mm

11105 Length 80 mm

EQUIPMENT REQUIRED



Drill Bit Kits Ø 4.8 mm

- 11001 Length 180 mm
- 11002 Length 240 mm

ADDITIONAL INSTRUMENTATION

The additional instrumentation required comprises:

- Wire Driver Attachment
- Mallet
- Benders

Unless sterile, when products are used for the first time, they should be removed from their containers and properly cleaned using a medical grade solution of alcohol in distilled water, minimum strength 70%.

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. Prior to surgical use, the fixator, bone screws and instrumentation 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].

The XCaliber Fixator is strictly single patient use.

Please refer to Manual 1, "Orthofix External Fixation: Basic Considerations" for more information on equipment maintenance.

SELECTION OF RING SIZE

Four ring sizes are available and may be used as full circumference rings or 2/3 circumference rings. Generally the 2/3 ring will be selected for the knee, since it facilitates knee bending and is more comfortable for the patient. With 2/3 rings, wire crossing angles are limited to about 70°.

The appropriate size may be selected by placing the rings around the limb and ensuring clearance of at least 1.5-2 cm between the ring and the limb.

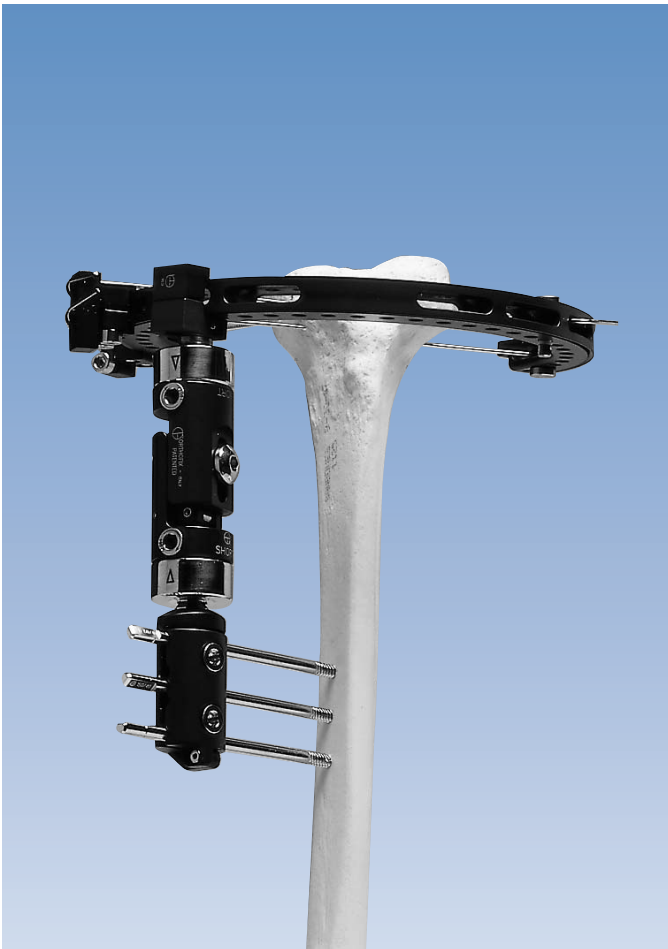
The following table may be used as a general guide to ring size selection:

Segment	Build of Patient	Probable Ring
Knee	Slight	150 mm - 175 mm
Knee	Large	175 mm - 190 mm
Knee	Very large	190 mm - 220 mm
Ankle	Slight	125 mm - 150 mm
Ankle	Large	175 mm

SELECTION OF RING/WIRE COMBINATION

Usually only one wire-bearing ring is used in the metaphysis. Crossed wires in the metaphyseal ring are preferred at two levels rather than at one level, provided that 20 mm of sound bone is available for their application. If less bone is available, single level wires may be used and if necessary, a further level of stability may then be achieved by extending the fixation across the adjacent joint.

Occasionally, two wire-bearing rings with two wires in each ring and connected by bolts may be used, if there is sufficient room in the bone.

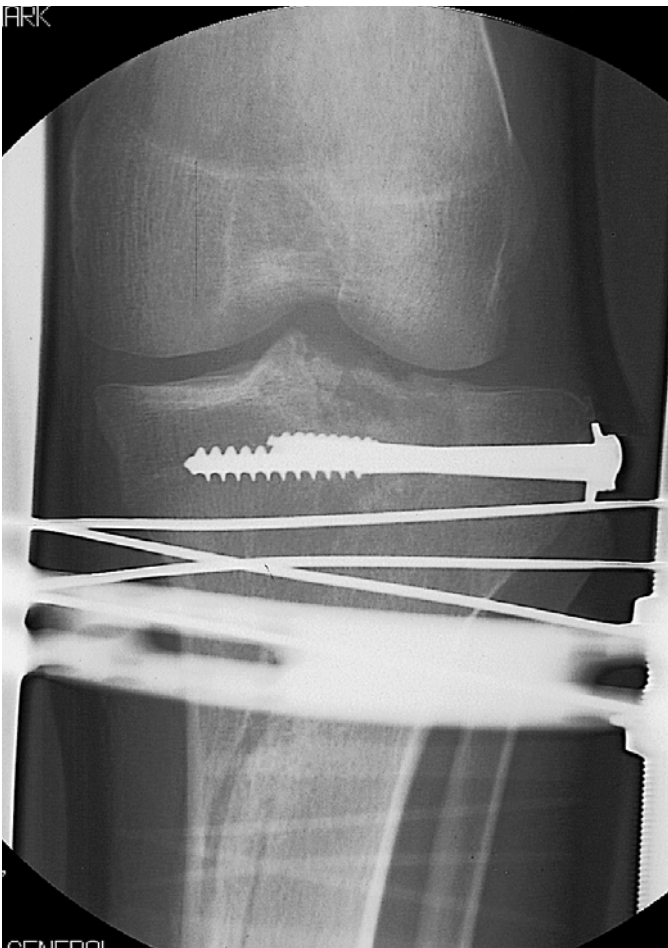


Metaphyseal Fractures without Articular Displacement

In the case of short spiral fractures involving the knee joint with little or no displacement, and short oblique fractures of the diaphyseal-metaphyseal junction, the frame should be applied with two to four wires proximally and two or three screws distally.

In longer spiral fractures, which often occur in the older age groups, improved fixation in the proximal fragment may be achieved using two rings connected by bolts.

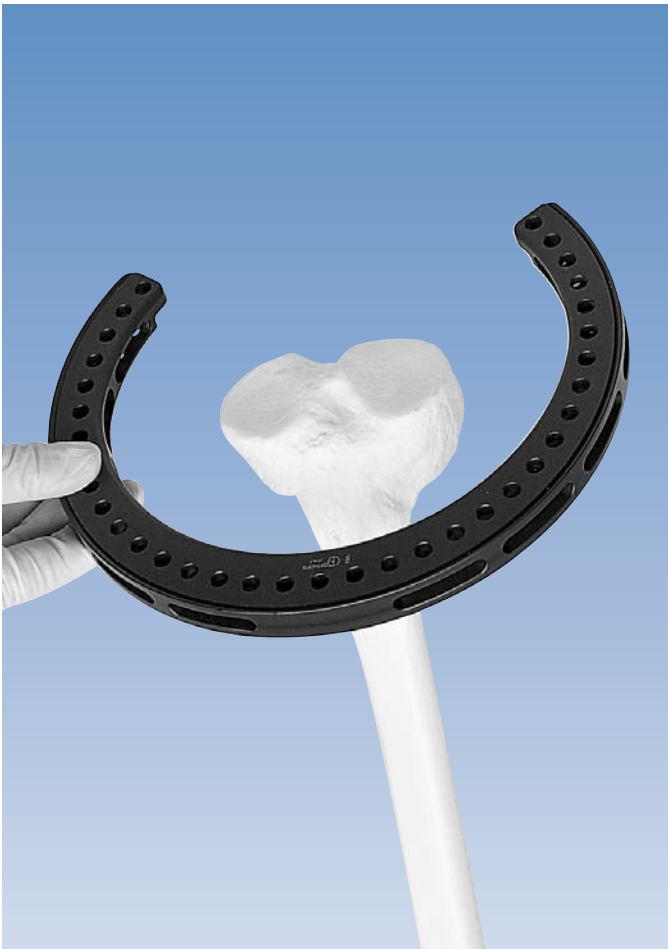
In longer spiral fractures, which often occur in the older age groups, improved fixation in the proximal fragment may be achieved using two rings connected by bolts. In this case, instead of a trans-fibular wire in the lower ring, a wire is placed more anteriorly in the coronal plane, to avoid the common peroneal nerve.



Displaced Articular Fractures

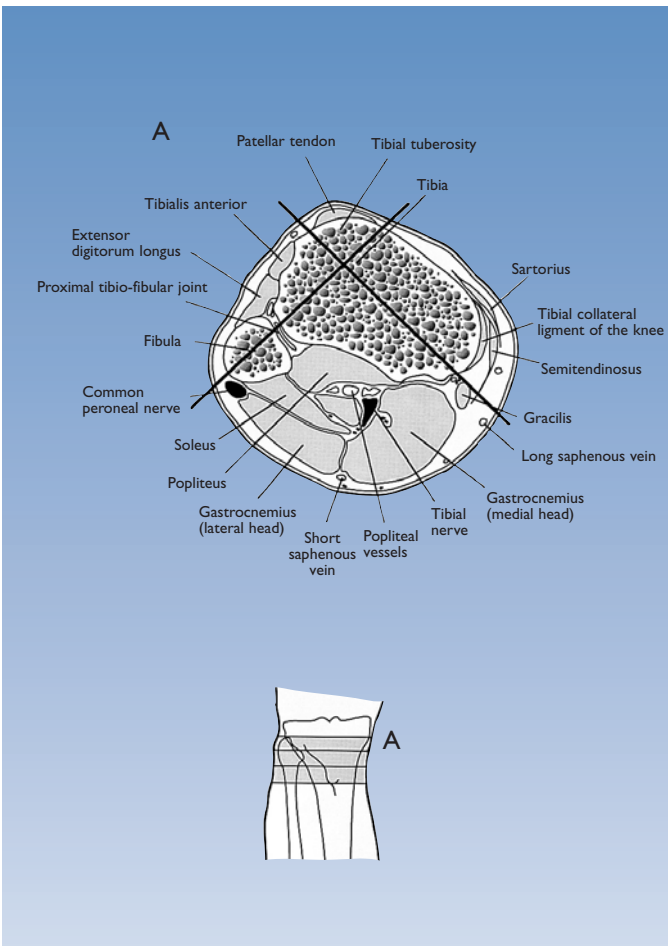
The fracture may be reduced by a standard arthrotomy² or by limited percutaneous approaches^{3,4} using cannulated interfragmentary screws and/or the Orthofix Fragment Fixation System implants inserted under image intensification. CT scan assessment combined with percutaneous articular reduction and external fixation permits safe, early, accurate reconstruction even in cases where the soft tissues are compromised. Normally, three to four wires should be applied proximally. In Schatzker 6 fractures, a configuration with four wires has been shown to be biomechanically appropriate^{5,6}.

In low energy spiral fractures, if reduction can be achieved by a closed procedure there may be no need for any additional internal fixation.



PRE-OPERATIVE PLANNING

The orientation of the fracture lines and extent of depression of the articular surface is determined. Important landmarks should be marked on the skin. CT scans are helpful. Temporary fracture reduction is secured using tenaculum forceps and guide wires inserted through stab incisions in the skin. If the reduction proves more difficult, direct reduction techniques with bone levers and punches inserted through limited incisions may be required. Occasionally, mechanical distraction or formal open reduction is required. Cannulated screws are inserted in the subchondral bone to secure and compress the major fracture fragments. Smaller fragments may be secured using Orthofix Fragment Fixation System implants. Bone grafting of the subchondral area, if required, is performed at this stage, and a percutaneous harvesting method is preferred^{7,8}. The metaphyseal ring is now placed around the upper tibia ensuring that it is at right angles to the axis of the leg in AP and lateral views (remember that the plateau slopes 10° caudally). The ring is oriented so that the broad flange is anterior or externally rotated 5°-10° from this position, and the open area posterior. When using Kirschner wires, it is important to ensure that the path they will take will avoid tendons or neurovascular elements. In the region of important neurovascular structures, a 4cm incision should be made, dissecting the tissues down to the bone and inserting the wire under direct vision.



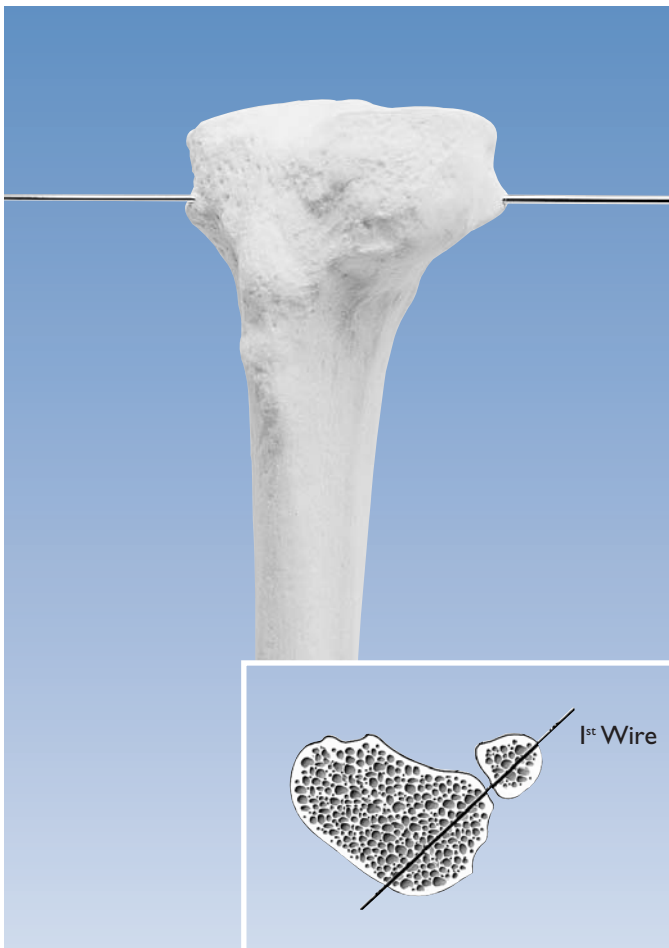
Safe Corridors for Kirschner Wire Insertion

When inserting wires in the proximal tibia, the head of the fibula is an important landmark, since the Common Peroneal Nerve passes posterior to it. Care should be taken to avoid transfixion of the Common Peroneal Nerve. Where two levels of trans-fibular wires are used, both should pass through the head of the fibula, or one through it and one just above its tip. In either case the upper wire should be sited at least 14mm from the joint line to avoid capsular penetration, and the lower wire must be above the neck of the fibula, where the Common Peroneal Nerve is at risk. A securing pin should be positioned upside-down with one hole above the ring proximally. The wire closest to the joint is inserted through this hole. The trans-fibular wire must avoid the Patellar Tendon, transfixion of which will cause pain and restricted motion. The crossing wire, called the medial face wire, is inserted just anterior to the antero-lateral compartment muscles, exiting at the postero-medial border of the tibia, anterior to the Gastrocnemius. It may cause some discomfort if it is too anterior, exiting through the Pes Anserinus (hamstring attachment), or too posterior, exiting through the medial head of Gastrocnemius. Transfixion of muscle leads to discomfort and restricted mobility. Should it be necessary to transfix a muscle, the appropriate joint should be moved to ensure that the muscle is stretched prior to insertion of the wire.

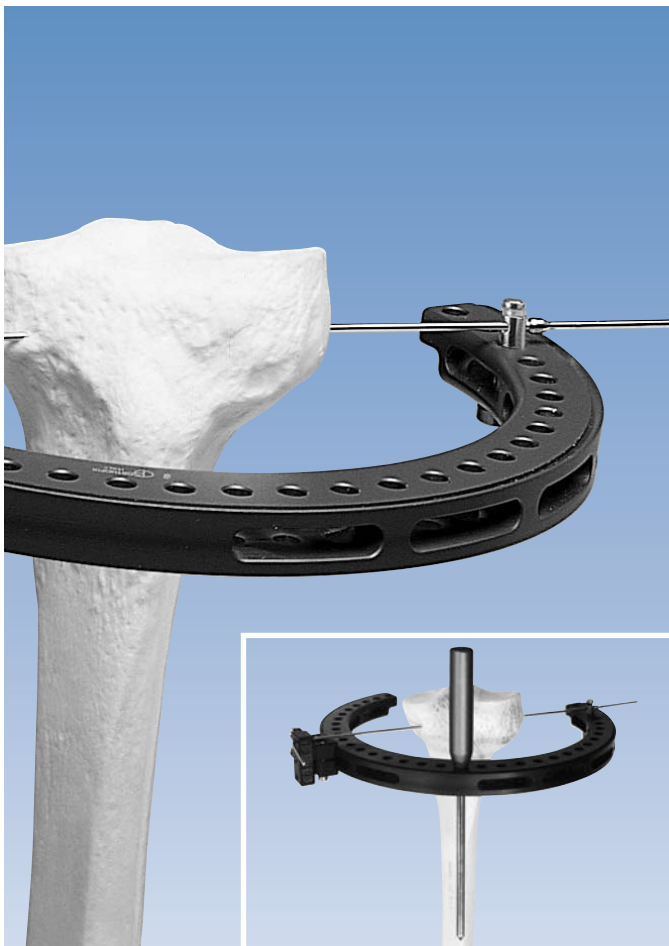
Kirschner Wire Insertion

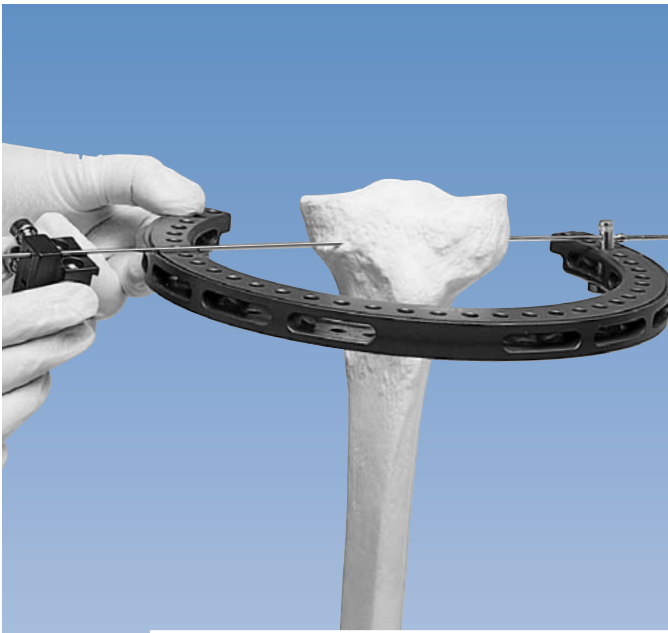
The first wire inserted (trans-fibular reference wire) is a postero-lateral to antero-medial one, through the head of the fibula, running parallel to the tibial plateau and exiting medial to the patellar tendon. It must be inserted below any internal fixation previously applied. It may be introduced either through a Kirschner wire securing pin, or alternatively, free-hand, using a wire without olive.

This wire often does not exit sufficiently anteriorly, resulting in a poor crossing angle. Be sure that it exits antero-medially (see inset).

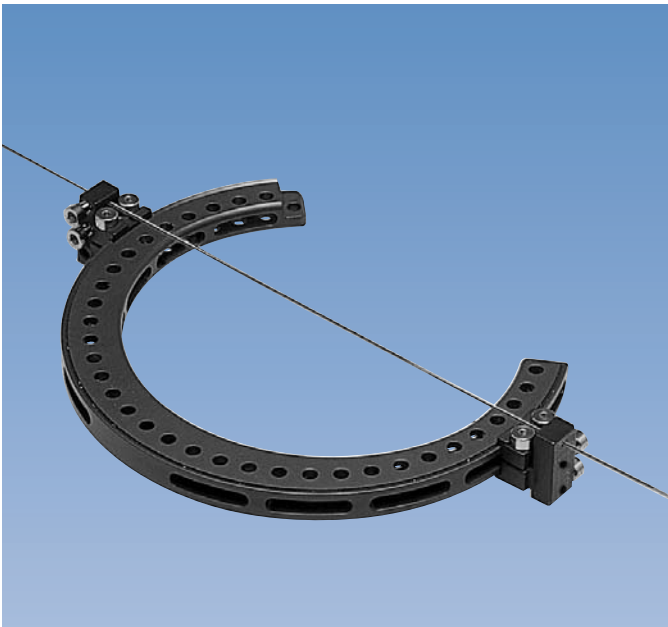
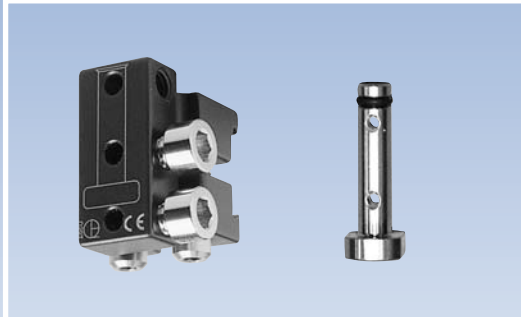


Where the wire is inserted through a securing pin, the ring is held in position by an assistant at 90 degrees to the tibial axis, with the limb centrally placed within the ring (it may be useful to position a trocar in the anterior hole in the ring and keep the trocar parallel to the tibial axis). In this case a wire with a lateral olive should be used. To insert the first wire, which is the one closest to the joint, the securing pin ring should be positioned upside-down with the hole above the ring. This allows better visualization of the wire during insertion. The wire is inserted percutaneously or through a small incision (3-4 mm) and pushed down to the bone before commencing drilling, which is carried out at slow speed and with gentle pressure. After it has penetrated the bone, it is tapped through the soft tissues on the far side, until the olive is against the securing pin.

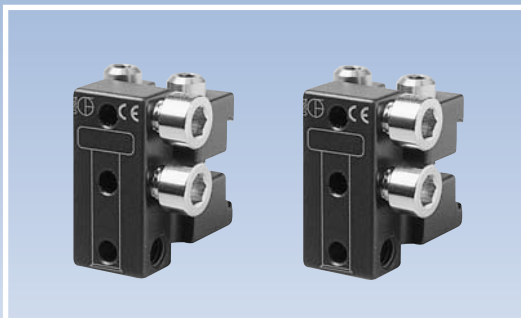


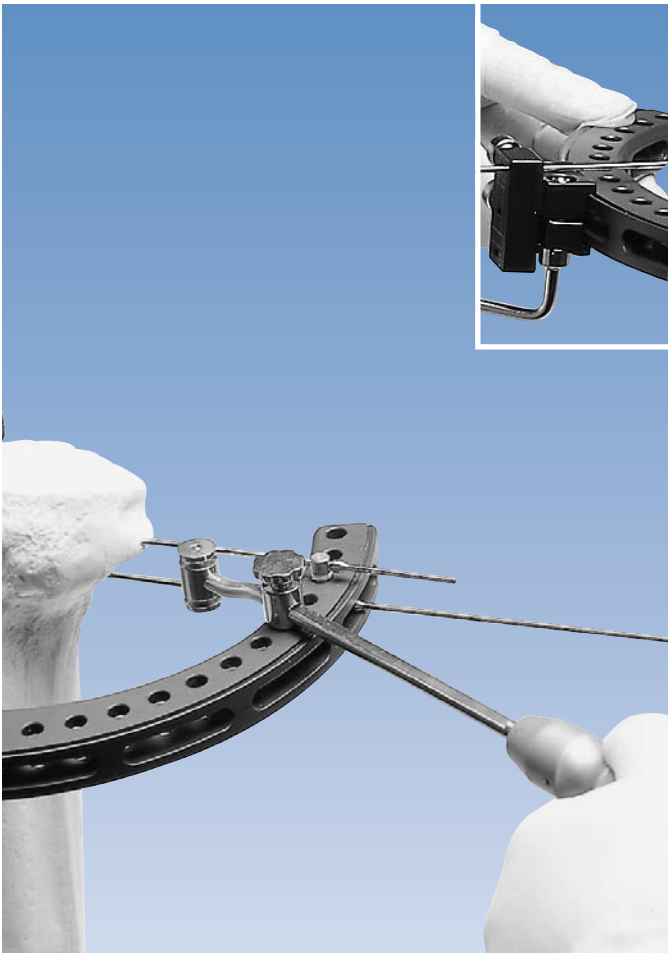


A three-hole wire clamp slider unit, with all screws loosened, is now oriented so that the etched outline of the securing pin on the clamp matches the position of the securing pin at the other end of the wire. The wire is inserted through the hole nearest to the joint, and the slider unit slid down to the ring.

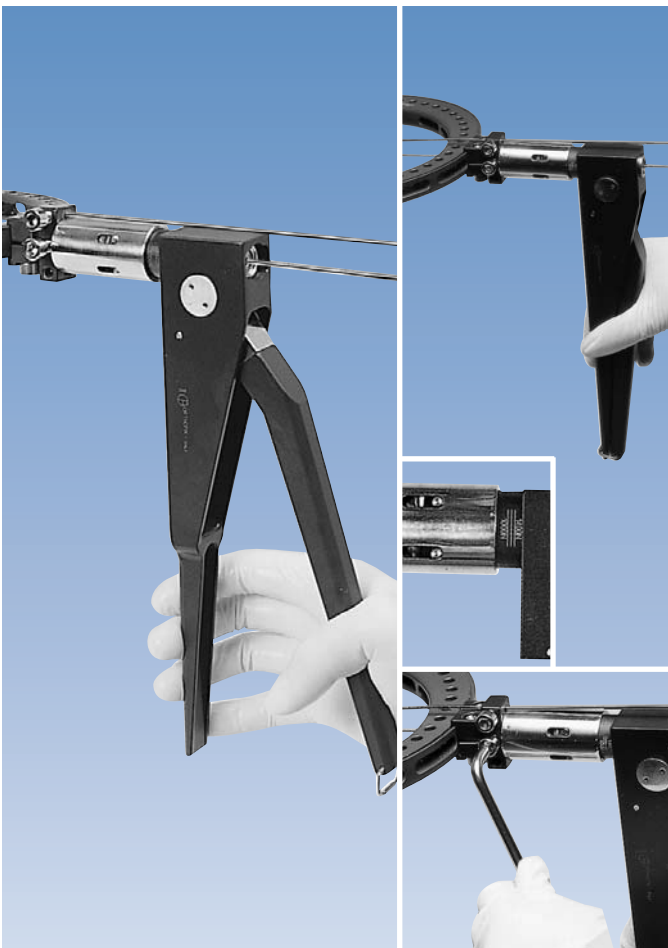


If the first wire is inserted freehand, a three-hole wire clamp slider unit is mounted on each end of the wire through the hole which will be nearest to the joint. Both slider units should be oriented the same way when they are attached to the ring.





The parallel wire is inserted next. The wire guide (18002) may be used to assist in this procedure. With its knob loosened, the sliding support unit of the wire guide is inserted into one of the holes in the ring and its position on the bar adjusted so that one groove in the head of the wire guide is in contact with the wire already in place. The second wire is then kept in contact with the remaining groove in the head of the wire guide during its insertion. The slider unit may be temporarily disconnected from the ring, and then inserted over both wires using the appropriate two holes. The slider unit is then firmly secured to the ring by tightening the appropriate screws evenly with a 3mm Allen wrench.

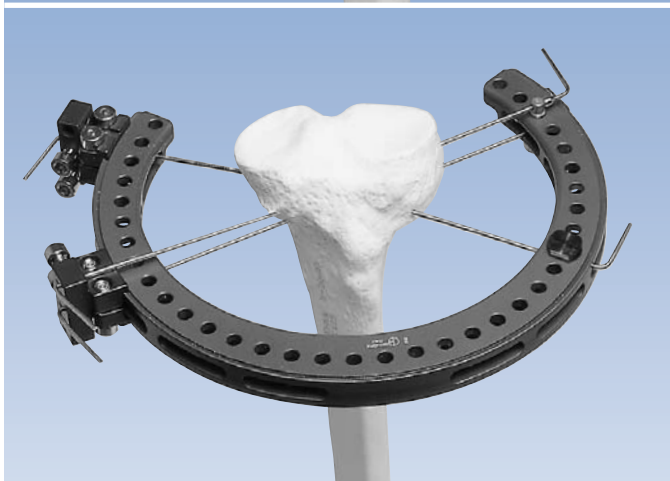


The ring must now be adjusted so that the limb lies at its center, since such adjustments cannot be made subsequently. Both wires are now tensioned, starting with the wire in the center hole. The wire tensioning device is opened fully and advanced over the wire until it touches the wire clamp slider unit. The handle is now closed and clipped, and the tension read off on the graduated scale. If it is less than 1200N, the wire clamp screw is temporarily tightened using the 5 mm Allen wrench and the procedure repeated. Once the correct tension is achieved (i.e. 1200N), the wire clamp screw is fully tightened.

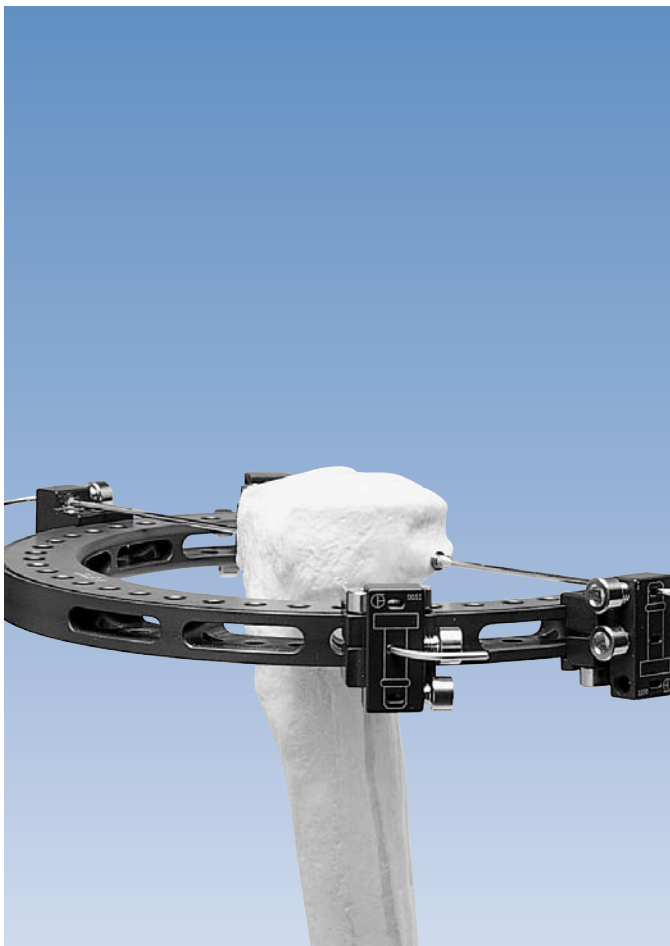
N.B. While tightening the wire clamp screw, it is important not to lever the wire tensioning device to avoid breakage of the Kirschner wire.



The Kirschner wires are now cut 4cm from the slider unit and bent at both ends. The cut end should be turned in towards the ring to avoid sharp edges being exposed, and a wire cover (**80200**) may be applied. Note that if the first wire of a pair is tensioned before the second is inserted, some difficulty may be experienced in guiding the second wire into the appropriate hole in the wire slider unit.



The position and direction of the crossing wires should allow a 50°-70° wire separation angle. Ring stability is optimal if the wire crossing angle is as large as possible and the wires cross in the center of the tibia. The crossing wires are now inserted, using the technique described above, taking care that the Kirschner wire securing pin is inserted from the OPPOSITE surface of the ring from that of the first pair of wires. This will ensure that the crossing wires are not in contact at the bone interface. These wires are now tensioned. Once tensioned, the ring may be considered to be securely attached to the metaphyseal segment. In order to avoid undue stress on a ring no more than two pairs of wires should be used on one ring.



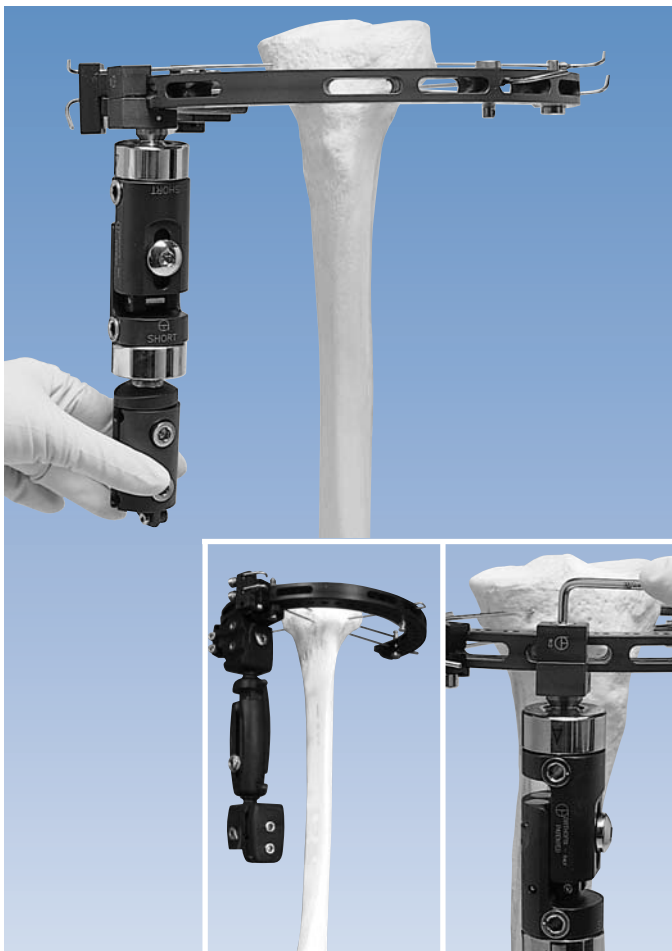
Wires with a central olive may be used in conjunction with a washer (**W2200**) where large translational forces are anticipated along the line of the wire, e.g. in any situation where narrow crossing angles may occur. The skin must be incised to permit passage of the olive through the soft tissue. As the olive cannot pass through a securing pin, the wire is inserted freehand, at approximately the height of the top hole of the wire clamp slider unit. Once the wire has been inserted, the slider units are attached and used to secure the wire to the ring. Wire tensioning is performed from the side distant to the olive, and tension should be reduced to between 800 and 1000N to avoid excessive pressure on the cortex of the bone.

Diaphyseal Screw Insertion

Once insertion of the Kirschner wires has been completed, the fracture is reduced by manipulation of the ring and the limb. While a theatre assistant maintains the reduction, the XCaliber Hybrid Fixator or a ProCallus fixator body of appropriate length with a ball-joint coupling (80050) is attached to the ring antero-medially in the tibia using the 3 mm Allen wrench.

The fixator body is opened by 1.5 cm, and held parallel to the long axis of the bone.

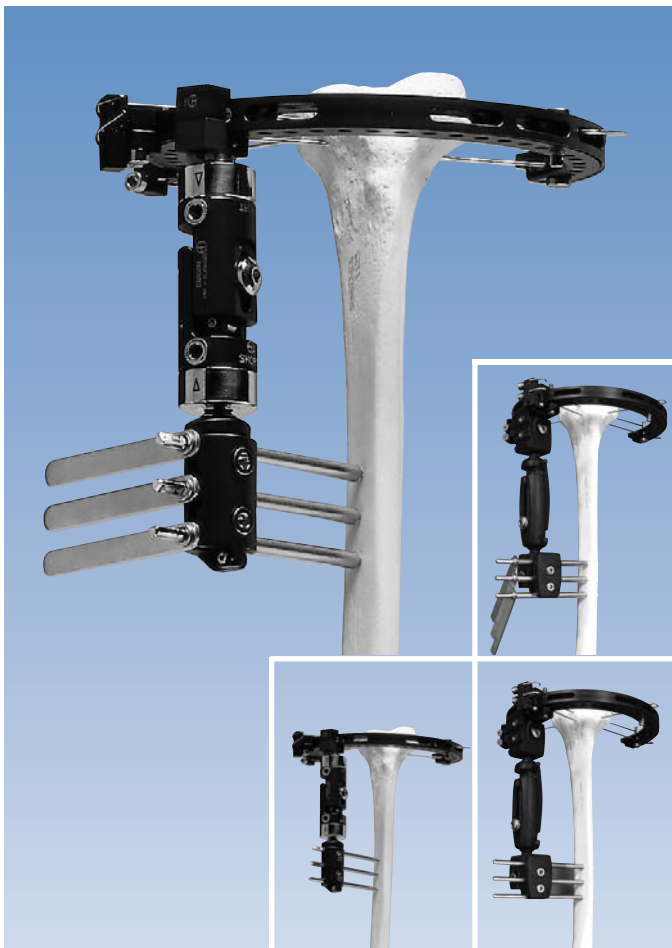
N.B.: A preassembled ProCallus fixator with ball-joint coupling (80051 standard and 80052 short) is available.



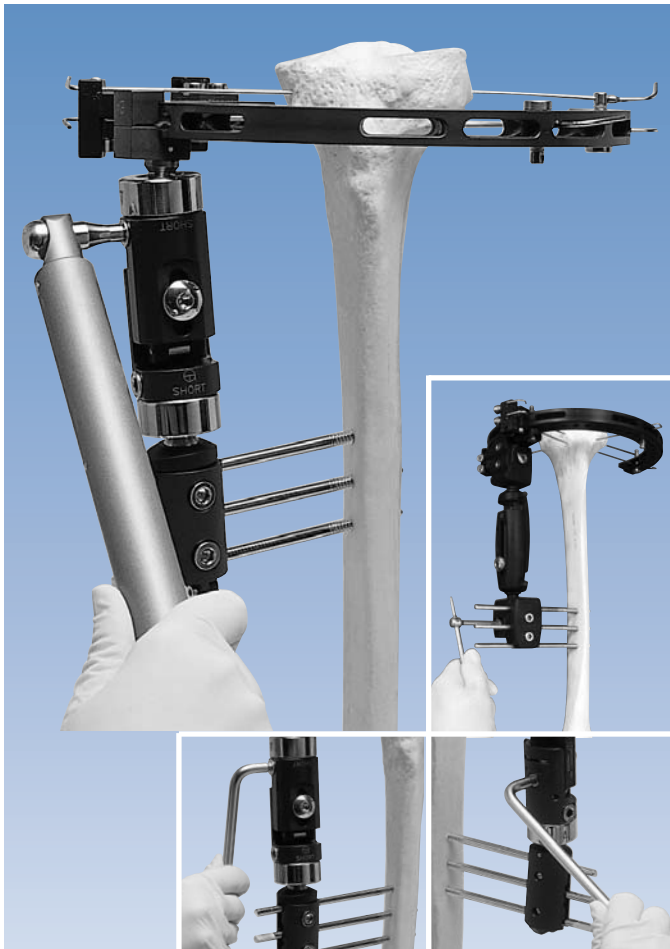
The diaphyseal screws are now inserted using the screw insertion technique described in Manual 1, “Orthofix External Fixation: Basic Considerations”. Screws (two or three) should be inserted at right angles to the diaphysis. Screws should be in positions 1 and 5 (two screws) or 1, 3 and 5 (three screws). In general, placement of three screws is advisable. Long screw guides are recommended: 80 mm screw guides should be used for the 150 mm and 175 mm rings and 100 mm screw guides for the 190 mm and 220 mm rings. When the second and the third screws are being inserted, the clamp cover must be tightened on to the screw guides, to ensure that the screws will be parallel to one another.

N.B.: Purchase is maximal if the screws are inserted across the widest part of the medullary canal.

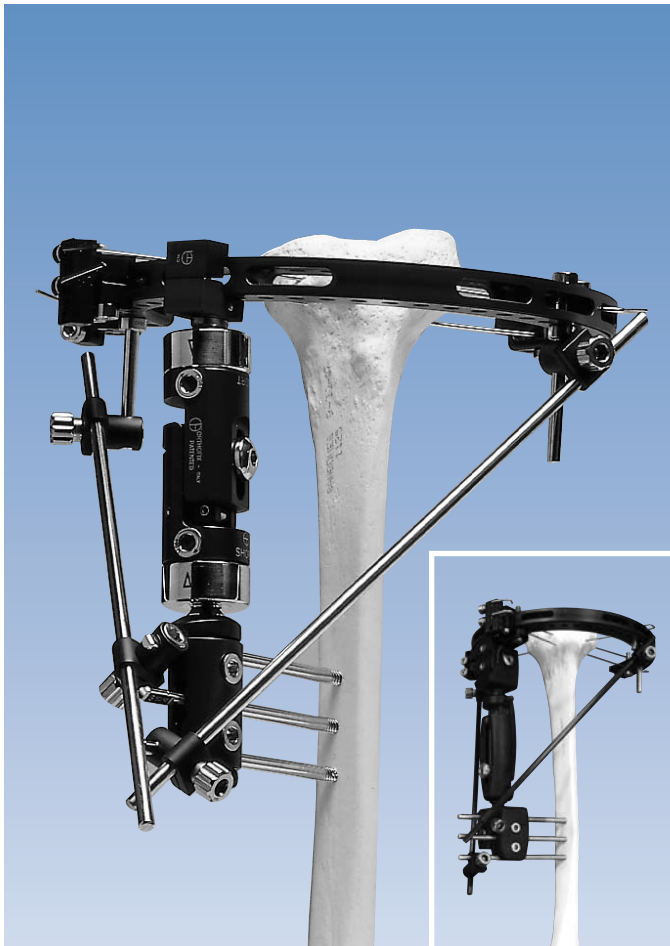
Once all the screws have been inserted, the screw guides are removed and the screw shafts washed free of blood before retightening the clamp cover. Tight skin around the screw sites should be released in the normal way.



PROXIMAL TIBIAL METAPHYSIS

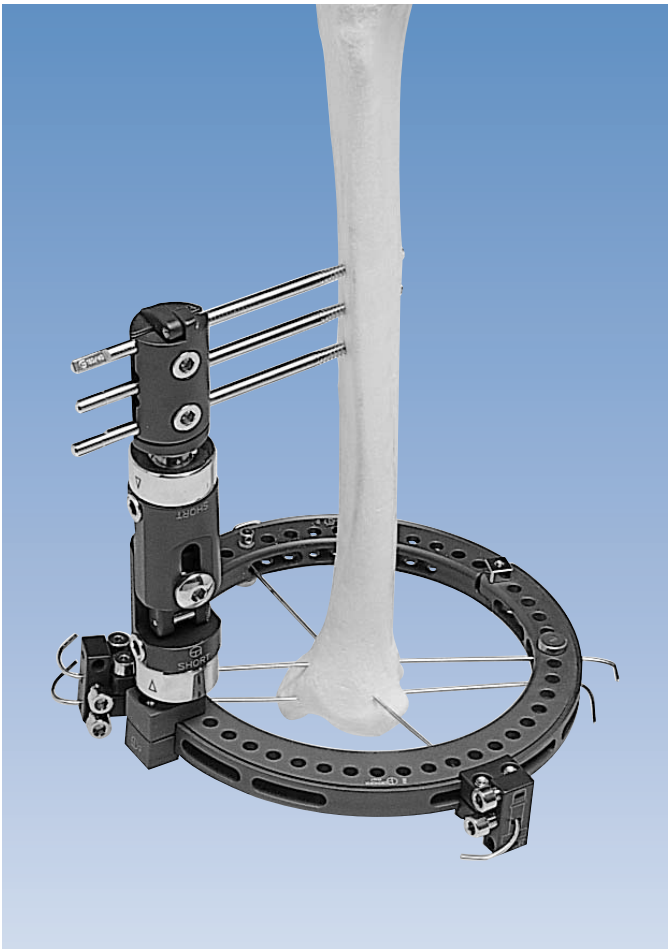


A final X-ray must now be taken to confirm reduction. The micromovement locking nut, the central body locking nut and the ball-joints of the fixator are now locked using the 6 mm Allen wrench. Final locking of the ProCallus ball-joints is performed using the torque wrench. A click indicates the correct torque. **The torque wrench should not be used for tightening anything else.**



Additional frame stability may be achieved with the use of reinforcement bars. Two posts are inserted through the ring and the bars attached to them using supplementary screw holder clamps. The other end of each bar is then attached to a bone screw using a further supplementary screw holder clamp.

As healing progresses, the reinforcement bars are removed to increase load sharing at the fracture site.



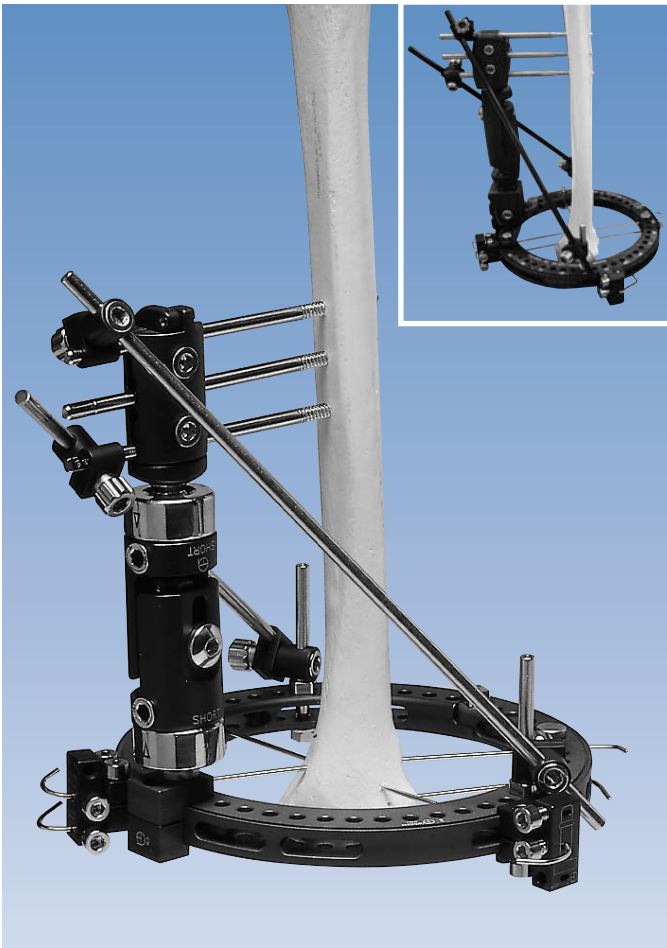
Metaphyseal Fractures without Articular Displacement

Short oblique distal tibial fractures at the diaphyseo-metaphyseal junction and short spiral fractures involving the ankle joint may be fixed with 2 or 3 screws in the proximal segment and 3 or 4 wires in the distal segment.



Displaced Articular Fractures

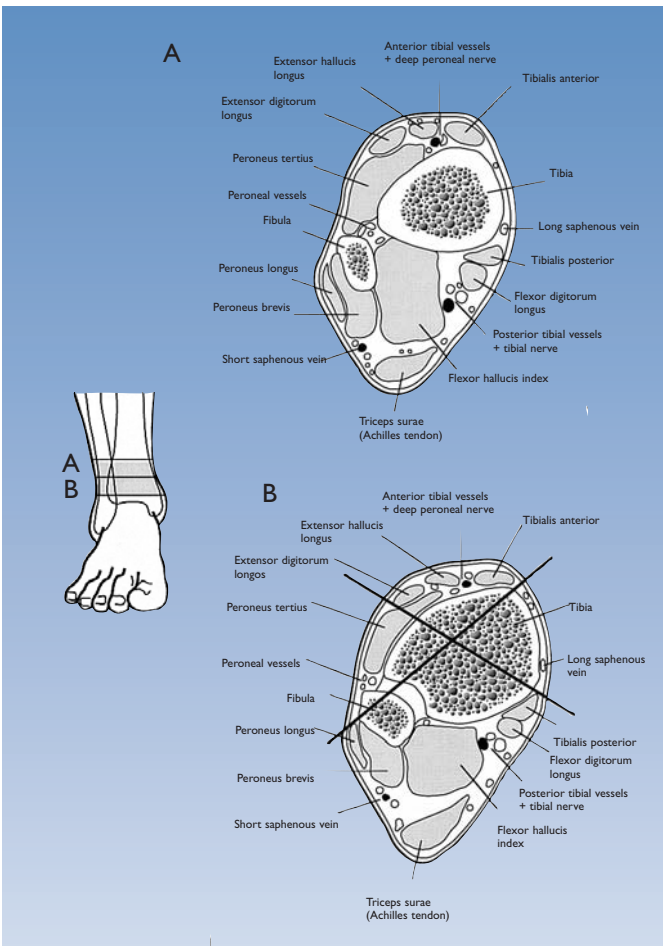
Where there is articular involvement, the frame may be applied after limited percutaneous reduction of the major articular fragments using either interfragmentary screws⁹ or the Orthofix Fragment Fixation System implants. In this situation sufficient room (10-20 mm) should be left between the articular surface and the internal fixation to place the wires. More comminuted and unreconstructable fractures should be treated by trans-articular fixation and articulated distraction^{10,11,12,13,14} although in some cases a primary ankle arthrodesis¹⁵ using external fixation, should be considered.



OPERATIVE TECHNIQUE

For Pre-operative Planning, see page 12 under “Proximal Tibial Metaphysis”.

The techniques of wire and screw insertion are similar to those in the Proximal Tibial Metaphysis (pages 13-18). The use of reinforcement bars should be considered in unstable fractures (page 18).



Safe Corridors for Kirschner Wire Insertion

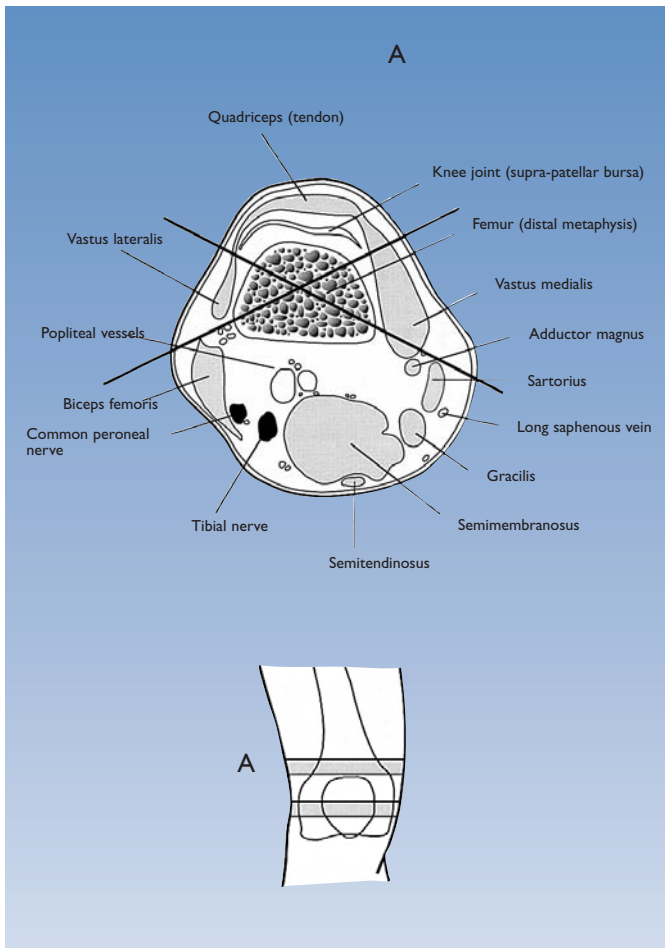
The first wire is trans-fibular from postero-lateral to antero-medial and is inserted between 5 mm and 10 mm from the distal articular surface of the tibia. It should pass medial to the Tibialis Anterior Muscle, thus avoiding the anterior tibial vessels. The crossing wire is from postero-medial to antero-lateral, and is inserted directly on to the subcutaneous edge of the tibia, thus avoiding the posterior tibial vessels and nerve.

It exits lateral to the tendon of Extensor Digitorum.

If two levels of wires are used, the first trans-fibular wire should be inserted close to the articular surface of the tibia so that the more proximal wire remains close to, or immediately above the level of the inferior tibio-fibular joint, in order to avoid the peroneal vessels.

All three neurovascular structures are potentially at risk. Transfixion of the Extensor Tendons must be avoided.

Wires are generally well tolerated and crossing angles of between 60° and 70° may be achieved.



Wire fixation in the distal femur is problematic because narrow wire crossing angles produce instability in the sagittal plane and transfixion of the medial and lateral periarticular structures may lead to intractable knee stiffness. Early joint motion may be instituted, but soft tissue movement over the wires may result in discomfort and early loosening.

Safe Corridors for Kirschner Wire Insertion

The first wire should pass from postero-lateral to antero-medial, anterior to the Biceps Femoris Tendon, and the second from postero-medial to antero-lateral, anterior to the Sartorius. The wires should be inserted with the knee flexed and early joint movement encouraged. It may be difficult to achieve crossing angles of more than 45°. In general, screw fixation is preferred to wire fixation, except in knee arthrodesis, where improved wire crossing angles may be achieved, as in this situation transfixion of the quadriceps and medial and lateral periarticular tissues is not a problem.

PIN SITE/WIRE SITE CARE

The visible parts of the screws and Kirschner wires, together with the surrounding skin should be cleaned on the day following surgery and at least once a day thereafter. Only sterile water should be used for this purpose. A dry absorbent dressing with additional gauze is used around the pin sites. After a few days, when they are dry, no dressing is needed.

Wires rarely require dressings unless skin releases are carried out. For the first 12 hours a padded dressing may be applied to the contralateral leg for protection.

There may be some loss of serous fluid from the pin sites, but this should not be mistaken for infection and is not a true complication. Normal pin site care is required.

Where inflammation is seen and the exudate is purulent, with the adjacent skin red and warm, a bacteriological swab should be taken and the appropriate antibiotic given for 7 to 10 days. Should local conditions not improve, more aggressive therapy may be needed, including possible removal of the screw(s) or Kirschner wire(s) involved.

If wire infection should occur, excess of soft tissue movement on the wires or loss of wire tension should be suspected.

Wire tension should be checked manually every two weeks. All securing elements, except for the wire locking screws, should be checked for tightness before discharge from hospital and every 4 weeks thereafter.

WEIGHTBEARING AND PHYSIOTHERAPY

Due to the particular nature of these fractures, partial weightbearing (25 kg) is permitted after 30 days. From 45 days onwards weightbearing may be progressively increased. Active and passive mobilization may be commenced immediately post-operatively. Weightbearing and physiotherapy should be instituted in accordance with stability, and guidance derived from radiological assessment.

DYNAMIZATION

During the post-operative period, the elasticity of the Kirschner wires will allow sufficient micromovement at the fracture site to stimulate callus formation. Dynamization by loosening the micromovement locking nut and the central body locking nut of the fixator is not, therefore, recommended with this assembly. Removal of the reinforcement bars is recommended when callus is first seen on X-ray, to increase load sharing at the fracture site.

FRAME REMOVAL

This is a rapid procedure which can normally be performed in the outpatient clinic using an aseptic technique. The patient should be given an appropriate dose of paracetamol (acetaminophen) 30 minutes prior to frame removal. The skin is prepared and the screws controlling wire tension loosened. Each wire is then cut inside the ring at the end opposite the olive. The cut section of the wire protruding from the skin is then cleaned and the wire pulled out from the side of the olive. The ring must be held stable until all wires have been removed. Patients will generally tolerate the removal of up to four wires at any one time. If wires with central olive have been used, the patient may experience increased discomfort and a small skin release under local anesthetic may be required.

These wires should **always** be removed by pulling on the end with the markings, which denote the position of the central olive. Screws are easily removed by turning them counterclockwise, which will immediately loosen them since they are conical in design.

If the patient is anxious, frame removal should be carried out under general anesthesia.

If the wires or screws are infected, the appropriate antibiotic should be administered orally, and frame removal delayed until the condition has improved.

- 1) BONIVENTO G. *Experience with a peri-articular attachment to the Dynamic Axial Fixator: a preliminary report*. Supplement to International Journal of Orthopaedic Trauma, 1993; 3(3): 52-54.
- 2) WEINER L.S., KELLEY M., YANG E., STEUER J., WATNICK N., EVANS M., BERGMAN M. *The use of combination internal fixation and hybrid external fixation in severe proximal tibial fractures*. J. Orthop. Trauma, 1995; 3: 244-250.
- 3) MARSH J.L., BONAR S.T., DO T.T. *External fixation and limited internal fixation for complex fractures of the tibial plateau*. J. Bone Joint Surg., 1995; 77A: 661-673.
- 4) FLOWERS M.J., CORT J., SALEH M. *External fixation and limited internal fixation for type C fractures of the proximal tibia*. J. Bone Joint Surg., 1995; 77B: Proceedings Supplement I, 4.
- 5) WATSON J.T. *High-energy fractures of the tibial plateau*. OCNA, 1994; 25(4): 723-752.
- 6) WATSON J.T. *Biomechanical stability of Schatzker 6 fractures treated with fine wire external fixation*. ASAMI NA Atlanta 1996.
- 7) SALEH M. *Bone graft harvesting: a percutaneous technique*. J. Bone Joint Surg., 1991; 73B: 867-8.
- 8) KREIBICH D.N., SCOTT I.R., WELLS J.M., SALEH M. *Donor Site Morbidity at the Iliac Crest: Comparison of Percutaneous and Open Methods*. J. Bone Joint Surg., 1994; 76B: 847-8.
- 9) TORNETTA P., WEINER L.S., BERGMAN M., WATNICK N., STEUER J., KELLEY M., YANG E. *Pilon Fractures: treatment with combined internal and external fixation*. J. Orthop. Trauma, 1993; 7: 489-496.
- 10) SALEH M., FERN D., SHANAHAN M.D.G. *Intra-articular fractures of the distal tibia. Surgical management by limited internal fixation and articulated distraction*. Injury, 1993; 24(1): 37-40. Selected for Critical reviews Clinical Digest Series in Orthopedics/Rheumatology.
- 11) BONAR S.K., MARSH J.L. *Unilateral external fixation for severe pilon fractures*. Foot and Ankle, 1993; 14: 57-64.
- 12) MARSH J.L., BONAR S., NEPOLA J.V., DECOSTER T.A. *Use of an articulated external fixator for fractures of the tibial plafond*. J. Bone Joint Surg., 1995; 77A: 1498-1509.
- 13) EASTAUGH-WARING S.J., WELLS J., SALEH M. *The use of the Goodall Targetting Device for application of external fixators in the treatment of pilon fractures*. Injury, 1995; 26(8): 567-568.
- 14) WISNIEWSKI T.F., RADZIEJOWSKI M.J. *Combined Internal and External Fixation in Treatment of Pilon Fractures*. SA J. Bone and Joint Surg. 1996; VI(2): 12-21.
- 15) O'DOHERTY D.P., STREET R., SALEH M. *The use of circular external fixators in the management of complex disorders of the foot and ankle*. The Foot, 1992; 2: 135-42.

EXTERNAL FIXATION

- PM 010 ORTHOFIX EXTERNAL FIXATION:
BASIC CONSIDERATIONS
- 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

- IS-02002-OPT Intramedullary Skeletal Kinetic Distractor:
Tibial Surgical Technique
- IS-03002-OPT Intramedullary Skeletal Kinetic Distractor:
Femoral Surgical Technique
- PM AAN The Ankle Arthrodesis Nail
- 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
- VN-0702-OPT ORTHOFIX TROCHANTERIC NAIL
- CN-0701-OPT The Centronail Titanium Universal Femoral Nailing
System
- CN-0702-OPT The Centronail Titanium Tibial Nailing System
- CN-0703-OPT The Centronail Titanium Supracondylar and
Retrograde Nailing System
- CN-0704-OPT The Centronail Titanium Humeral Nailing System

Orthofix wishes to thank

Prof. M. SALEH

Honorary Professor of Orthopaedic and Traumatic Surgery, University of Sheffield.
Private Practice, Norwich, UK.

**for his invaluable help
in the preparation of this manual**

Manufactured by: ORTHOFIX Srl
Via Delle Nazioni 9
37012 Bussolengo (Verona)
Italy

Telephone +39-0456719000
Fax +39-0456719380



Your Distributor is:

Deformity Correction | Trauma | Pediatrics | Bone Growth Stimulation